US Army Corps
of Engineers®
Los Angeles District

Little Colorado River
Feasibility Study Report

APPENDIX D
Design

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TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF PLATES

PLATE

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1.0 OBJECTIVE

The purpose of this appendix is to provide results from the Engineering Design analysis for the multiple design alternatives considered for the Little Colorado River (LCR) at Winslow feasibility study. Design data and calculations were developed sufficiently to determine the technical and economic feasibility of each alternative and in the event the project is authorized, to provide a base design leading to the development of the construction plans and specifications. The objective of the LCR Feasibility Study is to investigate alternatives for flood risk reduction to the Winslow Community.

2.0 STUDY AREA

The study is located in the city of Winslow, county of Navajo, Arizona, approximately 55 miles east of the intersection of Highway 17 and Interstate Highway 40 (I-40) in the northeastern portion of Arizona, at the confluence of the LCR and Ruby Wash. The LCR generally runs from south to north near Winslow. Ruby Wash joins the LCR just south of State Route (SR) 87. The existing Ruby Wash Diversion Levee generally runs in an east-west direction (see Plate 1)

The City of Winslow is located on the Colorado Plateau in Navajo County, Arizona, at an elevation of 4,880 feet above sea level. Winslow is the largest city in Navajo County, approximately twice the size of the county seat of Holbrook. Winslow is located on I-40 along the western border of Navajo County. Flagstaff is located 55 miles to the west, and Albuquerque lies 265 miles to the east. The state capital of Phoenix is located 133 miles to the southwest of Winslow.

The study area includes the floodplain of the LCR from the Clear Creek confluence downstream (northwest) to the northern end of the existing Winslow Levee (WL). The 49-square-mile study area encompasses the majority of the City of Winslow, including the Ruby Wash Diversion Levee and the Ruby Wash Levee. The tributaries of Ruby Wash, Clear Creek, Cottonwood Wash and Salt Creek join the LCR mainstem within the study area.

The City of Winslow has a long history of flooding along the LCR and its tributaries. There is an immediate need to reduce the risk of property damage caused by flooding in the City of Winslow and the surrounding communities. More importantly, there is a need to reduce the risk of loss of life, and safety caused by flooding.

3.0 EXISTING LEVEES

3.1 Winslow Levee (WL)

The approximately 7.3-mile long WL was constructed along the west side of the LCR by the Navajo County Flood Control District (NCFCD) and the Arizona Department of Water Resources between 1986 and 1989. The levee design included bank protection and cutoff walls. The WL was designed to contain the 100-year flood flow of 65,000 cfs. Recent studies indicate that the levee no longer provides 100-year flood protection. The levee was de-accredited by the Federal Emergency Management Agency (FEMA) in 2008, placing 2,700 parcels and 1,500 structures within the 100- year floodplain.

On January 8, 1993, the levee was overtopped by a flood event having an estimated peak discharge between 57,000 cfs and 75,000 cfs. As a result, a 400 foot section of levee was washed out, while a 3,000 foot section of levee was damaged. Properties (both private and public) were flooded in Ames Acres, Bushman Acres, and other areas behind the levee. In total, 204 parcels were inundated and 140 structures (both private and public) were damaged. A lawsuit resulted, which required $1,400,000 in Navajo County funds to settle. Temporary repairs to the levee were completed immediately following the flooding. Permanent repairs were completed in 1994 using FEMA, State, and County funds.

On December 31, 2003, the levee experienced a piping failure at well below a 100 year flood event (16 foot flood water elevation vs. a 25 foot elevation for a 100 year event). Fortunately, an alert citizen reported the impending levee failure and Navajo County responded immediately. Catastrophic failure was avoided by depositing material on the riverside of the levee. Permanent repairs matching the original design were completed in 2005. A later investigation of the cause of the failure found that the bentonite core was intact, and the piping was induced by sandy subsoil beneath the levee core.

Hydraulic models recently completed by Delph Engineering (under contract with the U.S. Army Corps of Engineers [USACE], Los Angeles District) indicate that the levee, in its current condition, will overtop in approximately the same location that it did in January of 1993 at a discharge of 55,000 cfs. This is approximately the 2% annual chance of exceedance (50-year) flood. The floodplain study concludes that the WL does not have the capacity to contain the 1% annual chance of exceedance (100-year) flood and does not meet FEMA standards for 100-year flood protection due to sediment deposition and a deficiency in levee height.

FEMA's standards for certifying levees for 100-year flood protection require that they have a minimum of 3 feet of freeboard. In addition to this, when the WL was designed, it was determined that another 2 to 3 feet of freeboard would be needed to provide storage for sediment that would build up within the channel over the life of the levee. So for most of the levee, the design freeboard was 5 to 6 feet. A comparison of the consultant's surveyed top-of-levee elevations with the

calculated 100-year floodwater elevations indicates that the levee is substantially deficient in height along much of its length.

Levee reconstruction is needed to reduce potential property damage caused by flooding in the City of Winslow and the surrounding communities. This action would also reduce the potential risk of loss of life, and safety caused by flooding. The existing levee cannot be strengthened or raised via partial reconstruction, or by adding material to the top and sides of the levee (refer to the existing levee condition described in the geotechnical appendix). Instead, it is necessary to rebuild the entire levee due to previous un-engineered design and construction leading to a poor foundation for the existing levee. Additional real estate is required to accommodate the new levee footprint. Rebuilding the levee requires existing utility crossings to be redesigned and reconstructed accordingly. Further design studies and construction plans will be needed before the work can begin.

3.2 Ruby Wash Diversion Levee (RWDL)

In addition to the WL, several other structures contribute to the current level of flood risk reduction for the City of Winslow. These consist of the Ruby Wash Diversion Levee and the Ruby Wash Levee. The USACE designed and constructed the RWDL. This levee is a rock and soil embankment extending 5.3 miles from the high ground near the southwest corner of the Winslow Airport to the LCR south of the Burlington Northern Santa Fe Railroad Bridge east of Winslow. The construction of this levee was completed in 1970. Flows in Ruby Wash and in other streams crossing the alignment of the levee are diverted east to the LCR, eliminating flood hazards along Ruby Wash. The RWDL reduces the flood risk to the Winslow Airport and approximately 500 residents.

3.3 Ruby Wash Levee (RWL)

The Ruby Wash Levee was constructed by the Arizona Department of Transportation in 1980 as part of the I-40 at Winslow Project (Project I-40-4(81). The Ruby Wash Channel extends from Third Street to I-40. Due to the flat terrain along the channel alignment, the channel was constructed using a small amount of excavation below the existing ground surface. The majority of the channel construction was accomplished by creating embankments of compacted earth fill above the natural ground elevation to form the channel banks, which are referred to as compacted earth fill levees.

Navajo County made substantial engineered improvements to the Ruby Wash Levee in the late 1990s. The levee provides flood protection for a portion of downtown Winslow. The levee met 44CFR 65.10 requirements prior to the FEMA Map Modernization program. The Ruby Wash levee is not included in the USACE Rehabilitation Program (RIP).

4.0 ALTERNATIVES

All alternatives described below include the nonstructural measure of improving the flood warning system.

4.1 Alternative 1.1 – Rebuild Levee System

Alternative 1.1 consists of rebuilding the entire WL and the eastern end of the RWDL along their current alignments, constructing a new levee parallel to I-40, and improving conveyance under the Burlington Northern Santa Fe (BNSF) Railroad Bridge with channelization and salt cedar tree removal. New levee construction would be designed to provide three feet of levee height above the 1% annual chance of exceedance (ACE) water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

This alternative involves demolition and reconstruction of the entire WL and the eastern end of the RDWL. Reconstruction of the WL consists of a series of segments with different revetment improvements along the existing alignment. Improvements include soil cement and grouted/ungrouted riprap revetments on the levee river side slope. Soil cement is considered to provide better protection for the levee against impinging flows. Whereas, grouted/ungrouted riprap would be more feasible for areas that are not subject to impinging flows and located away from the flow path (See Plate 2).

Cross section of the soil cement levee has the flowing design dimensions:

- 16-ft drivable top width
- 10-ft to 15-ft height including 3-ft of excess levee height
- 1H:1V soil cement riverside slope protection
- 3H:1V gravel mulch landside slope protection
- 15-ft toe-down depth for the riverside slope.
- 5-ft deep key trench
- 6-ft deep trench drain

Grouted/ungrouted stone levee section requires the following design dimensions:

- 16-ft drivable top width
- 10-ft to 15-ft height including 3-ft of excess levee height
- 2H:1V grouted/ungrouted riprap riverside slope
- 3H:1V gravel mulch landside slope protection
- 15-ft toe-down for the riverside slope.
- 5-ft deep key trench
- 6-ft deep trench drain

The existing WL is offset by a 0.7 mile gap where the levee segments north and south of I-40 join the highway embankment. I-40 itself serves as a component of the levee system between the two segments of the WL. Since I-40 was not constructed to function as a levee, Alternative 1.1 includes a new levee parallel to the north side of I-40 to close the gap in the current levee system. This new

levee consists of compacted soil armored with 24-in grouted riprap on the riverside slope. Dimensions of the grouted riprap levee section are similar to the ones described above. Levee typical sections are shown on Plate 8.
Conveyance under the BNSF Railroad Bridge needs to be improved to provide the required design channel capacity for the 1% ACE (100-yr) flood event. This improvement consists of widening and deepening the LCR channel for a distance of approximately 2,500 feet in the vicinity of the BNSF Railroad Bridge. The improvement also calls for soil cement and grouted riprap slope protection under the bridge. A typical cross section of the configuration of the channel improvement can be seen in Typical Section "E" on Plate 9.

Removal of approximately 96 acres of salt cedar trees within the river, in vicinity of the I-40 is required for the channel to convey its design capacity. The salt cedar tree removal area is shown on Plate 2.

A trench drain along the landside of the levee to collect underground seepage, overland and storm water flows is required to prevent levee seepage and overtopping. Overland and storm waters collected by the trench drain shall be conveyed and diverted into the river via reinforced concrete box (RCB) culverts. Trench drain configuration and dimensions are shown on Plate 8.

4.2 Alternative 3.1 – Winslow Levee Setback

Alternative 3.1 would include rebuilding the northern end of the WL along its current alignment, setting back part of the WL, removing the original WL in the setback areas, rebuilding the eastern end of the RWDL along its current alignment, constructing a new levee parallel to I-40, and improving conveyance under the BNSF Railroad Bridge with channelization and salt cedar removal. New levee construction would be designed to provide three feet of levee height above the 1% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

Similar to Alternative 1.1, Alternative 3.1 also includes demolition and reconstruction of the Winslow Levee and the eastern end of the RWDL, but demolition and reconstruction of the Winslow Levee involves only the northern segment of the levee instead of the entire levee. The proposed soil cement and grouted/ungrouted riprap levee sections are similar to those presented for Alternative 1.1. Setting back part of the Winslow Levee so that the new alignment runs in a straight line in the north-south direction and removal of the original Winslow Levee in the setback segments are included in this alternative.

Alternative 3.1 includes construction of a new levee on the north side and parallel to I-40 to close the 0.7-mile gap in the levee system. This new levee consists of compacted soil armored with 24-in grouted riprap on the riverside slope. Dimensions of the grouted riprap levee section are similar to those described in Alternative 1.1.

This alternative includes same conveyance improvements at the BNSF Railroad Bridge as described for Alternatives 1.1.Removal of salt cedar in vicinity of Interstate I-40 is required for the channel to convey its design capacity. The salt cedar removal area is shown on Plate 3.

A trench drain along the landside of the levee to collect seepage, overland and storm water flows is required to prevent levee seepage and overtopping. Overland and storm water collected by the trench drain shall be conveyed and diverted into the river via RCB culverts. Trench drain configuration and dimensions are shown on Plate 9.

4.3 Alternative 7 -Nonstructural Measures Only

Alternative 7 would employ nonstructural flood risk management measures for residences located north of the Interstate I-40 only; no levee or conveyance improvements.

Alternative 7 is very different from the previous alternatives, in that there are no structural improvements to the Winslow Levee or the RWDL. There are also no conveyance improvements under the BNSF Railroad Bridge. The only improvements in this alternative are non-structural measures; such as adding a flood hazard warning system, raising structures, etc. The area where nonstructural measures would be implemented is shown as the square grid area in Plate 4.

4.4 Alternative 8: Homolovi I Levee Setback

This alternative involves rebuilding most of the WL along its current alignment, providing a set back of a 2,000-ft segment of the WL, removing the original WL in the setback area, rebuilding the eastern end of the RDWL, constructing a new levee parallel to I-40, and improving conveyance under the BNSF Railroad Bridge with channelization, and salt cedar removal. New levee construction would be designed to provide three feet of levee height above the 1% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

Alternative 8 is almost identical to Alternative 1.1, except it includes setting back 2,000 feet of the Winslow Levee across from the Homolovi I Pueblo. This levee setback is proposed to reduce the probability that meandering of the LCR will impinge on the levee embankment. This setback also opens up the flow constriction at this location to allow the river to have a steady state flow condition at this location (see Plate 5).

This alternative includes same conveyance improvements at the BNSF Railroad Bridge as described for Alternatives 1.1 and 3.1.

4.5 Alternative 9 – Levee Increment 1

Alternative 9 includes rebuilding the eastern end of the RWDL at its existing height, no improvements to the Winslow Levee, no conveyance improvements, and use of nonstructural measures for residences north of I-40. New levee construction at the existing levee height would convey up to approximately the 2.8% ACE (36-year) flood.

Alternative 9 is similar to Alternative 7, except that it also includes reconstruction of the east end of the RWDL (see Plate 6).

4.6 Alternative 10 – Levee Increments 1 & 2

This alternative involves using salvaged excavation materials from the Winslow levee and the RWDL to the maximum extent possible.

It includes rebuilding the Winslow Levee from the RWDL downstream to a point 0.8 miles north of North Road (STA 320+00, approximately 3.55 miles), no improvements to the Winslow Levee downstream of STA 320+00, set back of a 2,000-ft segment of the Winslow Levee across the LCR from the Homolovi I Pueblo, removal of the original Winslow Levee in the setback area, rebuilding the eastern end of the RWDL, constructing a new levee parallel to I-40, improving conveyance under the BNSF Railroad Bridge with channelization and salt cedar removal, and employing nonstructural measures for residences downstream of North Road. New levee construction would be designed to provide three feet of levee height above the 1% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

The proposed soil cement and grouted/ungrouted riprap levee sections are similar to those presented for Alternatives 1.1, 3.1 and 8 above.

A gravel/sand trench drain would be constructed as part of the levee feature to address the seepage problem. Local drainage would be collected by a proposed concrete V-north ditch located along the landside of the levee. Multiple interior drainage reinforced concrete box (RCB) culverts would be needed to accommodate the proposed levee.

This alternative includes same conveyance improvements at the BNSF Railroad Bridge as described for Alternatives 1.1, 3.1 and 8 above.

In summary, Alternative 10 would provide structural measures to address the flood risk for the most densely developed portions of the Winslow, with use of nonstructural measures to reduce the risk further downstream (See Plate 7).

4.7 Alternative 10.1 – Levee Increments 1 & 2 (1% ACE) 100-Yr Levee Heights

Alternative 10.1 is identical to Alternative 10, except that it does not include elevation of residences. Incremental evaluation of Alternative 10 showed elevating residences is not economically justified. As was the case for Alternative 10, new levee construction would be designed to provide three feet of levee height above the 1% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained. (see Plate 7.1)

4.8 Alternative 10.2 – Levee Increments 1 & 2 (4% ACE) Flood

Alternative 10.2 is an optimization of Alternative 10.1 that is designed to pass the 4% ACE (25-yr) flood. New levee construction would be designed to provide three feet of levee height above the 4% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

The 4% ACE flood can safely pass beneath the BNSF Railroad Bridge without the need for conveyance improvements. Therefore, Alternative 10.2 does not require channelization or salt cedar removal. Plate 7.2 presents the overall plan of the Alternative 10.2.

4.9 Alternative 10.3 – Levee Increments 1 & 2 (2% ACE) Flood

Alternative 10.3 is another effort to further optimize the economic benefits provided by Alternative 10.1. Alternative 10.3 is designed to safely convey the 2% ACE (50-yr) flood. New levee

construction would be designed to provide three feet of levee height above the 2% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

The 2% ACE flood will require conveyance improvements at the BNSF Railroad Bridge. These improvements consist of widening and deepening the LCR channel for a distance of approximately 2,500 feet in the vicinity of the railroad bridge as described for Alternatives 1.1, 3.1, 8, 10 and 10.1 above. Salt cedar removal would also be required as described for these alternatives. See Plate 7.3.

4.10 Alternative 10.4 – Levee Increments 1 & 2 (0.5% ACE) Flood

Alternative 10.4 is a final effort to optimize economic benefits by evaluating a project designed for the 0.5% ACE (200-yr) flood. New levee construction would be designed to provide three feet of levee height above the 0.5% ACE water surface elevation. The additional levee height would increase the assurance that the designated flood can be contained.

In addition to requiring higher levees, Alternative 10.4 would require more substantial modifications to the LCR channel to pass the 0.5% ACE flood. The channelization area would increase to 6,000 feet in length in the vicinity of the BNSF, SR 87 and I-40 bridges. Due to the larger channelization area, the salt cedar removal area would actually decrease from 96 acres to 74 acres. See Plate 7.4.

5.0 UTILITIES INFORMATION

There are multiple existing utilities located within the project construction corridor for each alternative, except Alternative 7- Non-structural Measures Only that doesn't require improvements. These utilities would require relocation, reconstruction, and/or protection-in-place. (see Plate 10). The following existing utilities are considered to impact or likely impact the project.

5.1 Winslow Irrigation District Inverted Siphons

There are two inverted siphons consisting of 30-in RCPs crossing underneath the east end of the RWDL. These two siphons were buried approximately 5 feet measured vertically from the existing ground surface to the top of pipe, and conflict with the proposed improvement for east end of the RWDL. Relocation and reconstruction of the two siphons would be necessary to accommodate RWDL toe-down design requirements. Relocation and reconstruction work would involve excavation, removal of the existing siphons, and reconstruction of new siphons to avoid impacting the proposed RWDL toe-down. This work would also include trenching, placement of new lines connecting the new siphons, and backfill.

5.2 Wooden Utility Poles and Overhead Power Line

Located approximately 200 feet east of the two inverted siphons mentioned above are two wooden utility poles with an overhead power line. The poles are located on either side of the RWDL, within the project limits. These utility poles conflict the RWDL improvement project and need to be relocated prior to construction.

5.3 Buried Telephone Cable

There is an abandoned buried telephone cable located at approximately STA 6+10 along the WL. This buried telephone cable is no longer active and in service, and therefore, there is no need to replace, relocate, or protect-in-place. It shall be removed off site during construction.

5.4 CenturyLink Fiber Optic Line

There is an existing a fiber optic line inside a 4-in diameter polyvinyl chloride (PVC) conduit that was buried approximately 8.65 feet below the existing ground surface at the closet manhole in vicinity of the WL. This fiber optic line is located underneath the WL, between WL STAs 6+00 and 7+00. Protection of the fiber optic line is required during construction for all alternatives, except for Alternatives 7 and 9 where nonstructural measures were considered. To protect the CenturyLink fiber optic conduit in place, it would be necessary to encase the fiber optic conduit in concrete encasement with slurry concrete anchors beneath the WL and WL riverside slope extending 20 feet from the levee toe-down at the determined intervals (10-ft center-to-center). In addition to encasing the fiber optic conduit beneath the levee and levee riverside slope, it will be necessary to encase the fiber optic conduit with concrete for an additional 30 feet out from the visible landside levee toe and 10 feet out from the last slurry concrete anchor on riverside levee.

5.5 Kinder-Morgan High Pressure Gas Line Crossing Nos 1, 2 & 3

The Kinder-Morgan high pressure gas line crosses the WL project limits at three locations; at approximately WL STA 6+45, STA 52+00, and STA 81+11.10. The pressure gas line is a 4.5-in outside diameter pipe buried at a depth above the design depth of the proposed WL toe-down.

Relocation of the pressure gas line to a sufficient depth to avoid levee toe-down penetrations would be needed for each of the crossings. It was estimated a total length of 1,200 feet of the gas line would need to be relocated. Relocation work would involve excavation, trenching, and shoring underneath the WL, WL landside, and riverside slopes to construct a new line. This relocation work would require temporary disruption of service of an existing line for a short period of time, but not to exceed 3 hours for connecting to a new line for each crossing.

5.6 APS High Tension Overhead Electric Line

High tension electric overhead lines that are located at approximately WL STA 9+00, within the project construction access easement, but not within the construction limits. These electric lines would need to be protected-in-place during construction.

5.7 ADOT K-3 Channel - Under I-40

The ADOT K-3 Channel is located under and along the I-40, at approximately WL STA 59+68. This channel is not located in the construction area. Therefore, the current project design does not include K-3 channel flows. The K-3 channel flows would be diverted along the north toe of the I-40 embankment. The final levee design would be refined during Preconstruction Engineering and Design (PED) to avoid impacts the K-3 channel

5.8 ADOT 4-Cell 4-ft X 10-ft RCB Culvert with I-4 Hydraulic Lift Gate

The ADOT 4-cell 4-ft by 10-ft RCB culvert including hydraulic lift gate is located at approximately WL STA 92+13.41. This ADOT structure would need to be rebuilt/reconstructed in place due to impacting the proposed project construction area. Reconstruction of the RCB culvert including lift gate would consist of demolishing of the existing structures and reconstructing in-kind.

5.9 Arena Light Poles – Overhead Lighting

There are four arena light poles that are located between WL STA 132+00 and STA 134+00, which may not need to be relocated due to minor adjustment of the levee control line (realignment). Realignment of the levee can be accomplished during the PED phase.

5.10 Winslow Homolovi Water Line

An existing 6-in diameter PVC potable water supply line for Homolovi State Park is located at WL STA 158+00. This 6-in PVC water line that runs parallel to the WL landside slope for an approximate distance of 1,000 feet would need to be relocated and replaced with the new 6-in PVC line or equivalent. Relocation work would be accomplished in a manner that does not require service interruptions. However, during final connection of the new line to the existing line, temporary interruption to potable water service may be needed. It is anticipated that interruption to this 6-in PVC service would not last more than 2 hours.

5.11 Winslow Wastewater Outfall

The Winslow Wastewater Outfall is the National Pollutant Discharge Elimination System (NPDES) - permitted wastewater treatment discharge point for the City of Winslow. It is located at WL STA 223+00 and impacts the proposed WL improvement project for Alternatives 1.1, 3.1 and 8. The discharge pipe consists of a 12-in diameter ductile iron with outlet structure located approximately 100 feet off of the visible riverside toe of the levee. The outlet structure includes a

12-in flap valve and a reinforced concrete headwall. Relocation of the Winslow Wastewater Outfall including the outlet structure would involve construction of the new outfall and outlet structure and demolition of the existing outfall. Relocation work would be accomplished in a manner that does not require service interruptions. However, during final connection of the new wastewater line to the existing wastewater line, temporary interruption to wastewater service may be necessary. It is anticipated that interruption to the wastewater line service would not last more than 2 hours.

5.12 APS Overhead Electric Lines, Wooden and Metal Power Poles

There are 9 utility poles within the vicinity of the project corridor for Alternatives 1.1, 3.1 and 8. Six of 9 poles are wooden poles and the remaining 3 poles are metal poles. These utility poles are located approximately between STA 223+00 and STA 242+00. These utility poles provide electrical service to the locals via overhead power lines. Two metal poles that are located within a few feet of the edge of the construction access corridor would not require relocation since there is enough space to provide a workable condition around the poles. One of the wooden poles has been broken and abandoned and would not need to be replaced, because this pole is no longer in service. Relocation of 6 utility poles would be necessary to accommodate project improvements. Relocation work for the wooden poles would involve installation of new poles including power lines and removal of the existing poles. Work required for relocation of the metal pole would involve installation of the new pole and power lines including construction of footing and demolition and removal of the pole and the concrete footing/base. Relocation work would be accomplished in a manner that minimizes service interruptions during relocation of the existing the poles. However, temporary interruption would be necessary to connect/reconnect the existing lines with the new poles during the final connection phase.

6.0 BORROW SITES

Two type of locations are considered as borrow sources located in the vicinity of the project, the Riverine and Upland. See Plate 12.

6.1 Riverine Borrow

There are two potential riverine borrow sites situated in the LCR. The first site consists of material from existing levee embankments and trench excavations, as well as LCR floodplain sediment deposited in the vicinity of the BNSF Railroad Bridge. This borrow site would be excavated to increase conveyance under the railroad bridge and to obtain the design flow capacity for all alternative except Alternatives 7 and 9 which called for nonstructural measures, and Alternative 10.2. The required excavation area to increase conveyance for Alternatives 1.1, 3.1, 8, 10, 10.1 and 10.3 would be approximately 26 acres. The required excavation area to increase conveyance for Alternative 10.4 would be approximately 81 acres. Sediment deposits are found to be suitable for levee construction.

The second borrow site is located near the upstream end of the project, north-east of the French Farm. This borrow site was established by oriented dust storms that formed a dust dune of an approximately 4.3-acres consisting of silt and fine-grained sandy silt. This dust dune material represents a potential source of fines.

6.2 Upland Borrow

Three sites located in the upland area have been identified as potential borrow areas for levee construction material. The first site is located directly east of French Road and north of Oaks Road, right next to the WL project. This site is owned by the City of Winslow consisting of two contiguous 80-acre parcels that extend into the LCR floodplain. Of the total 160 acres, approximately 45-acres is available for use. Geotechnical exploration has not been conducted for this site. However, the USACE study team examined available geologic maps, studied aerial photographs, and made conclusions concerning the site geology. The fine grained-sediments deposited over the years in the river could be used as fines for levee construction.

The second site, located at the northern end of the WL project, owned by Mr. Jim O'Haco, identified as "O'Haco Northwest" pit, provides a borrow source of upland material. This 39.2-acre site was used to mine for levee construction materials consisting of silty sandy clay. The material was also used for repair of the WL. Although this site is considered a good borrow area, it is located about 2.5 miles from the project's downstream end, which is further away from the project as compared to the first and third borrow sites.

The third site is an existing operating gravel and sand quarry, the Dyna Sand and Rock/Winslow Ready Mix site, owned by Mr. John McCauley. It is located near the southern end, on the east side of WL, about 0.7 miles east of the extent of the levee.

7.0 DISPOSAL SITES

Five sites have been identified available for disposal of excess and waste material resulting from project construction. Refer to Plate 12. These sites are described as follows:

7.1 McCauley Site

John McCauley has offered the Dyna Sand and Rock/Winslow Ready Mix property for disposal. The property consists of three contiguous parcels totaling 503 acres, located near the upstream end, on the east side of WL (north side of I-40, between SR 87 and the LCR). This property is currently used for concrete and aggregate processing operation/facilities, and a borrow pit.

7.2 City of Winslow Site

This site consists of two contiguous 80-acre parcels. Approximately 45-acresare available for disposal. An agricultural area is located on the south end of the property, therefore disposal is limited to north end only.

7.3 O'Haco North Site

The O'Haco North Site consists of approximately 50-acres of a 242- acre parcel located at the far northern end of the WL. Maximum disposal area allowed at this site is 6.3 acres.

7.4 O'Haco Middle Site

The O'Haco Middle Site consists of a 37-acre portion of the same 242-acre parcel on which the O'Haco North Site is located. LCR meanders creating a C-shape to separate the O'Haco North and O'Haco Middle sites. Maximum disposal area allowed for this site is 9.5 acres.

7.5 O'Haco South Site

The O'Haco South Site consists of a 400-acre parcel that extends into the LCR floodplain. Approximately 57 percent of the 400-acre parcel is located on the landside of the WL. The remaining 43 percent is situated in the levee floodplain (riverside). A maximum area appropriate for disposal is 32.8 acres.

8.0 CONTRACTOR'S STAGING/STOCKPILE AREAS

The staging/stockpile areas have been identified and indicated on Plate 11 for all the alternatives, except Alternative 7-Nonstructural Measures Only that doesn't require staging/stockpile areas. Multiple staging/stockpile areas ranging from two to five acres per site have been identified and indicated for Alternatives 1.1, 3.1 and 8. Alternative 9 would require two -2-acre staging/stockpile areas due to limited levee improvements. Up to eight staging/stockpile areas would be needed for each of the remaining alternatives. In addition to staging/stockpile areas, a batch plant site would be needed for concrete and grouting operations for installation of soil cement and grouted stone slope. This batch plant site would be located on a 5-acre lot owned by the City of Winslow, except for Alternative 3.1, for which the batch plant would be located on property owned by the Navajo Tribe or Transcon, LLC.

9.0 INGRESS – EGRESS ROUTES

Seven ingress/egress routes required for access to the project upstream to downstream have been identified and indicated on Plates 2, 3 and 5 for Alternative 1.1, 3.1 and 8, respectively. Two ingress/egress routes would be needed for alternative 9 because of limitation of levee improvements. Six ingress/egress routes would be needed for access to the project upstream and downstream for Alternative 10, 10.1 and subsequent alternatives (see Plates 7, 7.1 through 7.4). It is proposed to have 30-ft width two-way ingress/egress routes to allow safe passage of heavy construction equipment.

10.0 CONSTRUCTION CONSIDERATIONS

10.1 Construction Period and Seasonal Compatibility

The proposed construction plan would be implemented via multiple phases. Each construction phase would consist of demolition of the existing levee and construction of a new levee, extension of interior drainage and associated features including the trench drain and collector channel. The construction time required for multiple construction phases is estimated to be 4 to 8 years depending on the selected alternative. The estimated construction time assumes an approximately six month levee construction period each year. Construction would generally occur from May through October, when the risk of flooding along the LCR mainstem is minimal. Construction phasing would be accomplished in a manner that assures a functioning levee system during each winter-spring rain and snowmelt season. Since freezing winter temperatures and high summer temperatures occur at Winslow, placing of materials should be planned for periods of mild weather.

As a result of the proximity of the river to the construction site, the construction period should be scheduled to coincide with a time of year when the flooding risk would be minimized. The risk factor could have significant impact on the construction cost of the project. The embankment work would be most susceptible to damage and construction delays during the wet season of the year. Winslow experiences both summer and winter rains; however, the primary rainy season is the winter with most peak flows occurring in the months of November through April in association with heavy rain and snow melt events. Avoidance of these months to the extent possible in scheduling construction would be advantageous.

The estimated first cost of the levee includes estimates for construction, rights-of-way, and relocation of people (Alternative 3.1 only) and utilities. Allowances for contingencies, engineering and design, and supervision and administration of construction are also included in estimated first costs.

10.2 Material Sources

Due to relatively fair to good soil characteristics and the proximity of residential and agricultural developments to the levee, it was determined that the area within the river and adjacent to the levee would provide a suitable source for the materials required for compacted earth fill and soil cement construction. The material in this area consisted primarily of fine silt and sandy soils.

The closest source for large basalt is the existing, operating Brimball Hardluck Quarry, in Indian Wells, AZ, 40 miles north of Holbrook on SR 77. This location is 43 straight-line miles northeast of the Winslow Levee. The quantity of stone available should not be an issue. The material was tested prior to placement on the Winslow Levee by Navajo County contractors. Although there are some slight variations from the standard USACE test suite, all indications are that the stone would pass the USACE stone acceptance criteria. An existing quarry located approximately 60 miles from the southern end of the Winslow Levee was used to supply the riprap for the existing levee. This quarry was located in Bidahochi, AZ, and operated under the name 'Bidahochi Quarry'.

10.3 Estimated Installation Cost

The total estimated project installation costs are the expected expenditures for construction, contingencies, land rights, engineering, and contract administration. The average annual cost used in computing the benefit cost ratio reflects installation costs plus annual operation and maintenance expenditures (see Table 1).

An explanation of each of the components comprising the installation cost is presented below.

- Construction. This item provides money to be paid to a contractor for actual construction of the project and protection of the existing structures and utilities. The construction cost is estimated by applying a unit cost to required quantities of construction materials and then totaling the costs computed for each construction item.

- Contingencies. Contingency costs are included to provide an allowance for cost overruns resulting from unforeseen circumstances or unit price fluctuations that may occur during project installation.

- Land Rights. Land rights costs include obtaining the additional right-of-way needed for levee construction. These costs also include the anticipated relocation of water, power, wastewater, fiber optic and gas line utilities. Right-of-way costs give consideration to acquisition of land or easements, as well as associated land acquisition costs such as title report, appraisals, right-of-way, survey, and agent fees.

- Engineering and Administration. This category of expenditures includes the cost of final project design, contract administration, and construction inspection. These costs are normally estimated as a percentage of the construction cost.

Table 1 – Costs for Alternatives

Alternatives[1]		First Cost ($)	Operation and Maintenance (Annual)
1.1	Rebuild Levee System; 1% ACE Flood	$87,305,013	$102,000
3.1	Winslow Levee Setback; 1% ACE Flood	$91,703,551	$95,200
7	Nonstructural Measures (NS) Only	$19,172,028	$0
8	Homolovi I Levee Setback; 1% ACE Flood	$81,732,058	$99,000
9	Levee Increment 1 with Nonstructural Measures	$21,221,331	$5,850
10	Levee Increments 1 and 2 with Nonstructural Measures; 1% ACE Flood	$64,155,183	$67,800
10.1	Levee Increments 1 and 2 without Nonstructural Measures; 1% ACE Flood	$59,905,378	$67,800
10.2	Levee Increments 1 and 2 without Nonstructural Measures; 4% ACE Flood	$39,259,563	$24,800
10.3	Levee Increments 1 and 2 without Nonstructural Measures; 2% ACE Flood	$59,356,189	$67,000
10.4	Levee Increments 1 and 2 without Nonstructural Measures; 0.5% ACE Flood	$68,575,887	$91,300

[1] All Alternatives include Flood Warning System

11.0 OPERATION & MAINTENANCE

11.1 Operation

Operation of the proposed project will be the responsibility of NCFCD and will include, but not be limited to, periodic inspection.

11.2 Maintenance

The NCFCD is responsible for maintenance of the proposed project. In order to determine the need for specific maintenance items, routine inspections should be conducted every six months or twice per year and after any significant flooding. The inspection crew would consist of two laborers with a pickup truck. It is estimated that these inspections would require a maximum of four days per year. Each inspection would include a written report summarizing findings and recommending repairs that would correct any problems. Maintenance would include the following:

- Vegetation Control. Active or passive establishment of vegetation on the earthen portions of the levee would attenuate erosion. However, vegetation maintenance may be required to ensure levee integrity. Structures to be maintained include the landside face of the levee, top of the levee, and access roads along the levee. Salt cedar growth on the structure (especially the access roads) through natural recruitment is likely. The plant can grow from seedling to several feet within the span of one year. Hand removal and herbicide application would be sufficient in most cases. Spot mechanized mowing or mechanized removal could be required on a periodic basis. Mechanized equipment could consist of a mower, dump truck, back hoe, and a loader as well as crew vehicles. Annual vegetation management could require up to five laborers for a period of 15 days.

- Rodent Control. Burrowing animals are capable of perforating a levee with holes to the extent that the structural integrity of the levee may be jeopardized. To alleviate this problem, the rodent population should be kept under control by placing poison or traps in the burrows. Rodent problems should be identified during the quarterly inspections. Controlling this problem would require two laborers with a pickup truck and a supply of rodent poison or traps. It is estimated this program would require 48 hours per year per person.

- Levee and Interior Drainage Structures Repair. In order to maintain the integrity of the levee and interior drainage structures, it is anticipated some repairs will be required after periods of significant flooding. This would include replacement of earth fill along eroded sections of the levee and interior drainage structures, repairs to gated outlets, and replacement of any damaged sections of soil cement, grouted/ungrouted riprap and gravel. It is estimated that the majority of these repairs could be accomplished by a basic maintenance crew consisting of four workers utilizing one dump truck, one bulldozer, one frontend loader and a pickup truck. Over the life of the project, it is anticipated this crew would be engaged in levee and interior drainage structure repair work for two weeks per year.

- Sediment Removal Under the BNSF Railroad Bridge. Removal of accumulated sediments under and in vicinity of the BNSF Railroad Bridge is required when it is determined that loss of channel capacity due to sediment build up has been confirmed based on surveying the river cross sections as described below. The estimated channel length that requires sediment removal extends 2,450 feet (1,225 feet immediately upstream and 1,225 feet immediately downstream of the bridge

centerline). It is estimated the majority of the work could be accomplished by a sediment removal crew of six members utilizing two front-end loaders, one excavator and two dump trucks. It is expected that annual sediment removal could require a period of 15 days to complete the work.

- Survey River Cross Section. This item provides a means for determining the reaches of the river where significant sedimentation is occurring. Survey monuments would be established at several selected levee stations with respect to the river as part of levee construction. Thereafter, the cross sections of the river would be surveyed on a periodic basis and after each significant flood. The results of the survey would be compared to the original cross sections and a determination made regarding the loss of channel capacity due to sediment build-up. These periodic surveys would provide an indicator of the rate of freeboard loss or gain resulting from the sediment transport processes occurring in the river. It is estimated that the necessary survey work could be completed by a 5-man survey crew working an average of two weeks per year.

- Floodplain Management. Regardless of the implementation of the plan evaluated in this report, it is recommended that a floodplain management program be established to control development in the floodplain. If a flood control plan is adopted and implemented, floodplain management will ensure that the operation of the plan will not be compromised. It is extremely important that no development be allowed in the floodplain that would reduce the capacity of the system to pass the design flood. No annual costs are shown in the Annual Operation and Maintenance Costs table below for this item since it will be required before Navajo County participates in the National Flood Insurance Program for the unincorporated area around Winslow.

11.3 Environmental Commitment Measures.

- Removal of Woody Vegetation. To avoid impacts to migratory birds, work that would disturb or remove woody vegetation would not occur between April 15 and August 30 unless the affected area is first surveyed by a biologist and determined not to have nesting birds.

- Conducting Surveys of the Yellow-Billed Cuckoo and Southwestern Willow Flycatcher. Prior to the start of any O&M activities, surveys for the yellow-billed cuckoo and southwestern willow flycatcher will be conducted within suitable habitat, if present. If the yellow-billed cuckoo or flycatcher is detected within the project area, BMPs would be applied to avoid effects to this species.

    1) Follow-up treatments (e.g. mechanical and /or herbicide) of saltcedar would occur within saltcedar removal areas. This area would be reseeded and/or revegetated with native plantings.
    2) During any O&M activities during minimal flow periods (near impingement points, channel excavation/widening, etc.), BMPs would be incorporated to minimize negative impacts to the sensitive flannelmouth as well as other fish species. BMPs may include, but are not limited to the following: silt curtains, wattles, coffer dams, and erosion protection screens. These BMPs would help to prevent fish access to the work site and insure protection of water quality. BMPs would be inspected daily to maintain the connection to the substrate and would be removed following O&M activities.
    3) In addition, any vegetated areas that are disturbed from disposal, borrow, staging, stockpiling, or access, or other O&M related activities would be returned to pre-O&M conditions.

Table 2 – Annual Operation and Maintenance Costs

ANNUAL OPERATION AND MAINTENANCE COSTS							
Alternative	Periodic Inspections ($)	Vegetation Control ($)	Rodent Control ($)	Levee and Interior Drainage Repair ($)	Sediment Removal Under BNSF RR Bridge ($)	Survey Cross Sections ($)	Total Annual Costs ($)
1.1	8,000	15,000	2,400	20,200	32,400	24,000	102,000
3.1	8,000	13,000	2,400	15,400	32,400	24,000	95,200
7	0	0	0	0	0	0	0
8	8,000	14,000	2,400	18,200	32,400	24,000	99,000
9	500	1,000	350	1,500	0	5,850	5,850
10	4,000	7,500	1,400	10,500	32,400	12,000	67,800
10.1	4,000	7,500	1,400	10,500	32,400	12,000	67,800
10.2	2,000	3,500	800	8,500	0	10,000	24,800
10.3	4,000	7,500	1,400	10,500	32,400	12,000	67,000
10.4	5,500	7,500	1,400	12,500	50,400	14,000	91,300

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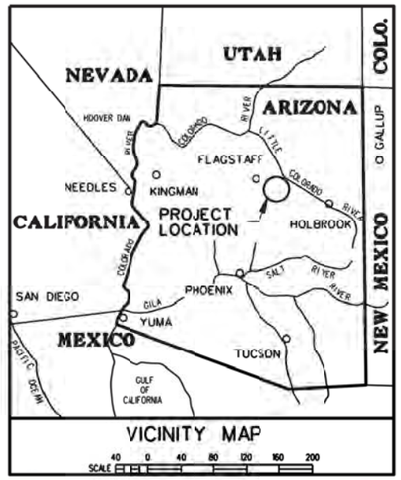


LEGEND

- 40 — INTERSTATE HIGHWAY
- 66 — STATE HIGHWAY
- U.S. 180 — U.S. HIGHWAY
- RAILWAY

LITTLE COLORADO RIVER AT WINSLOW
WINSLOW, ARIZONA

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME:

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

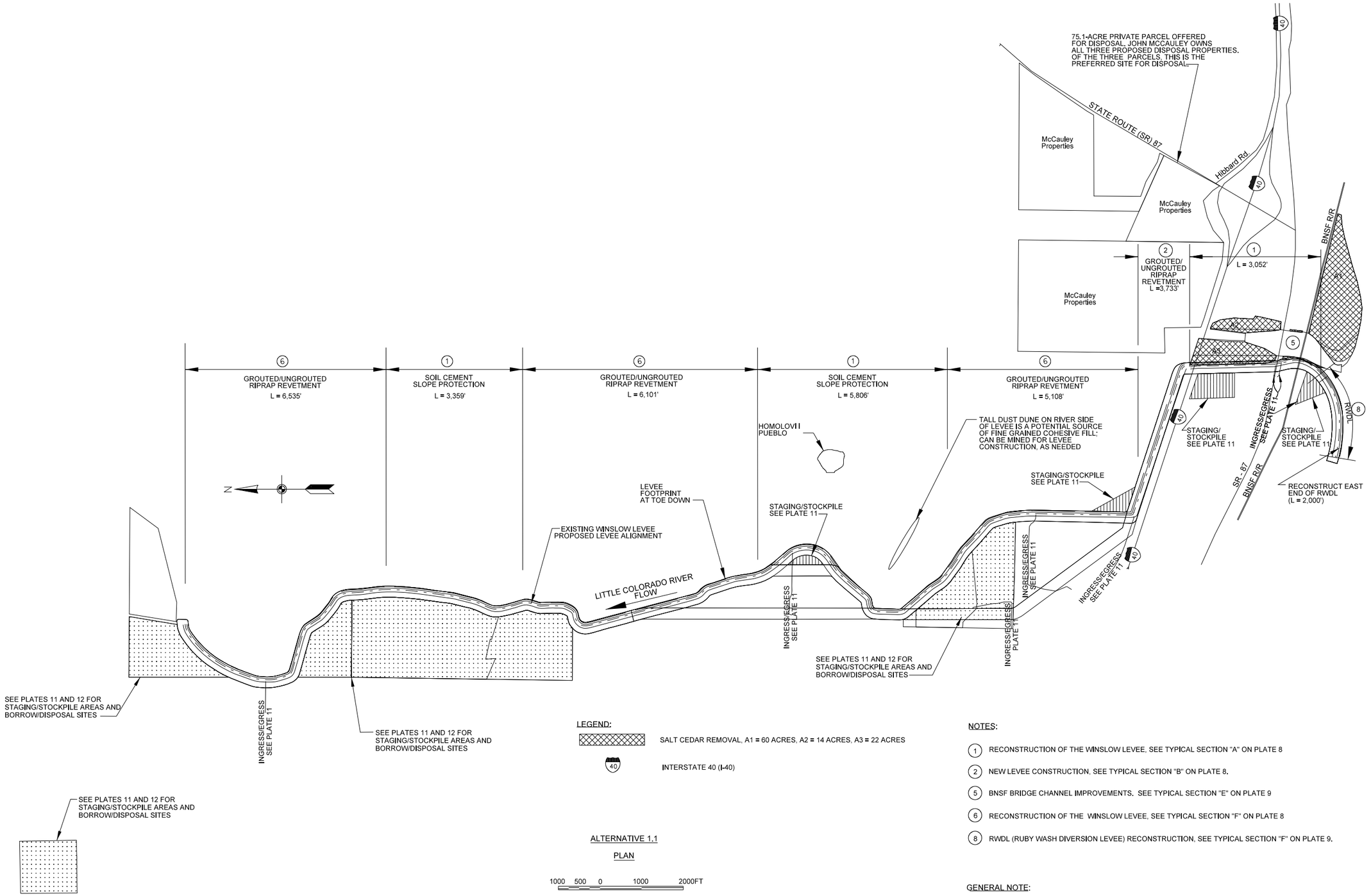
PROJECT LOCATION AND VICINITY MAP

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

PLATE
1

Plot Date: $date$



LEGEND:

SALT CEDAR REMOVAL, A1 = 60 ACRES, A2 = 14 ACRES, A3 = 22 ACRES

INTERSTATE 40 (I-40)

ALTERNATIVE 1.1

PLAN

1000 500 0 1000 2000FT

NOTES:

1. RECONSTRUCTION OF THE WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE CONSTRUCTION, SEE TYPICAL SECTION "B" ON PLATE 8.
5. BNSF BRIDGE CHANNEL IMPROVEMENTS. SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCTION OF THE WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_1.1.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

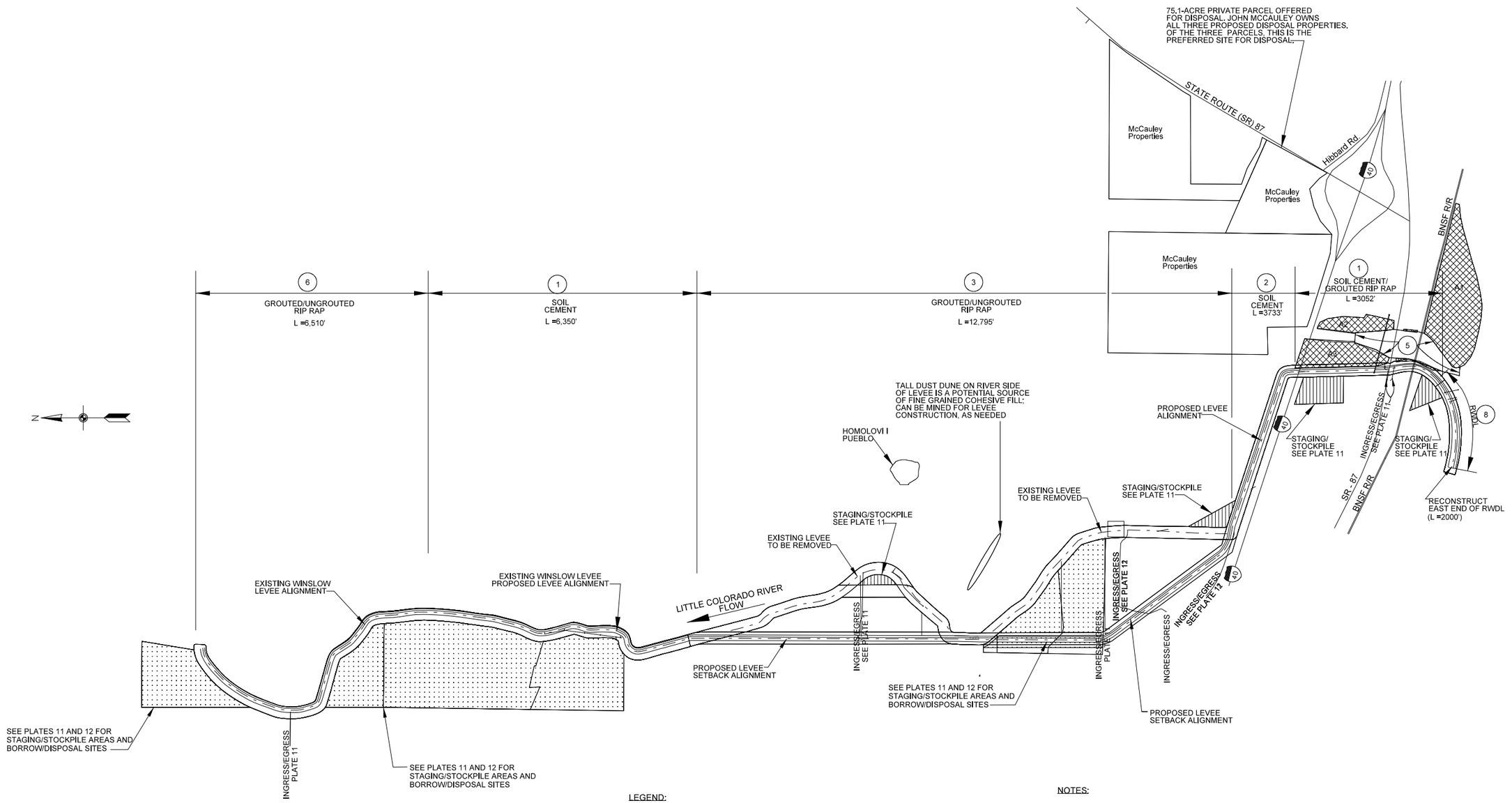
ALTERNATIVE 1.1
REBUILD LEVEE SYSTEM

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

PLATE
2

Plot Date: $date$



LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 60 ACRES, A2 = 14 ACRES AND A3 = 22 ACRES.

ALTERNATIVE 3.1

PLAN

1000 500 0 1000 2000FT

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
3. REALIGN/SETBACK LEVEE (NEW), SEE TYPICAL SECTION "C" OR "D" ON PLATES 8 AND 9
5. BNSF BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

DESIGNED BY:
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CHECKED BY:
FILE NAME: ALT_3.1.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

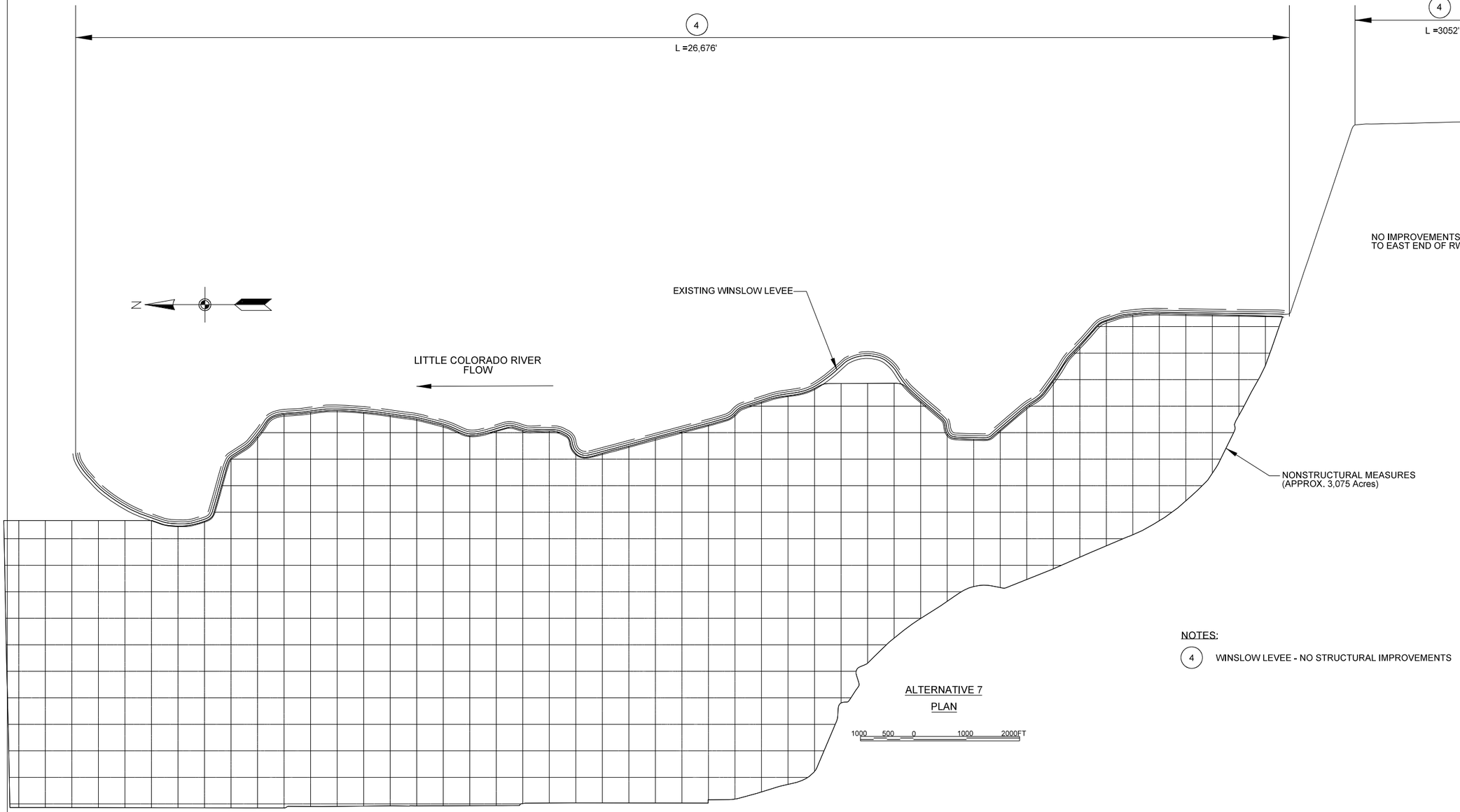
ALTERNATIVE 3.1
WINSLOW LEVEE SETBACK
PLAN

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

PLATE
3

Plot Date: $date$



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DRAWN BY:

CHECKED BY:

FILE NAME: ALT_7.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

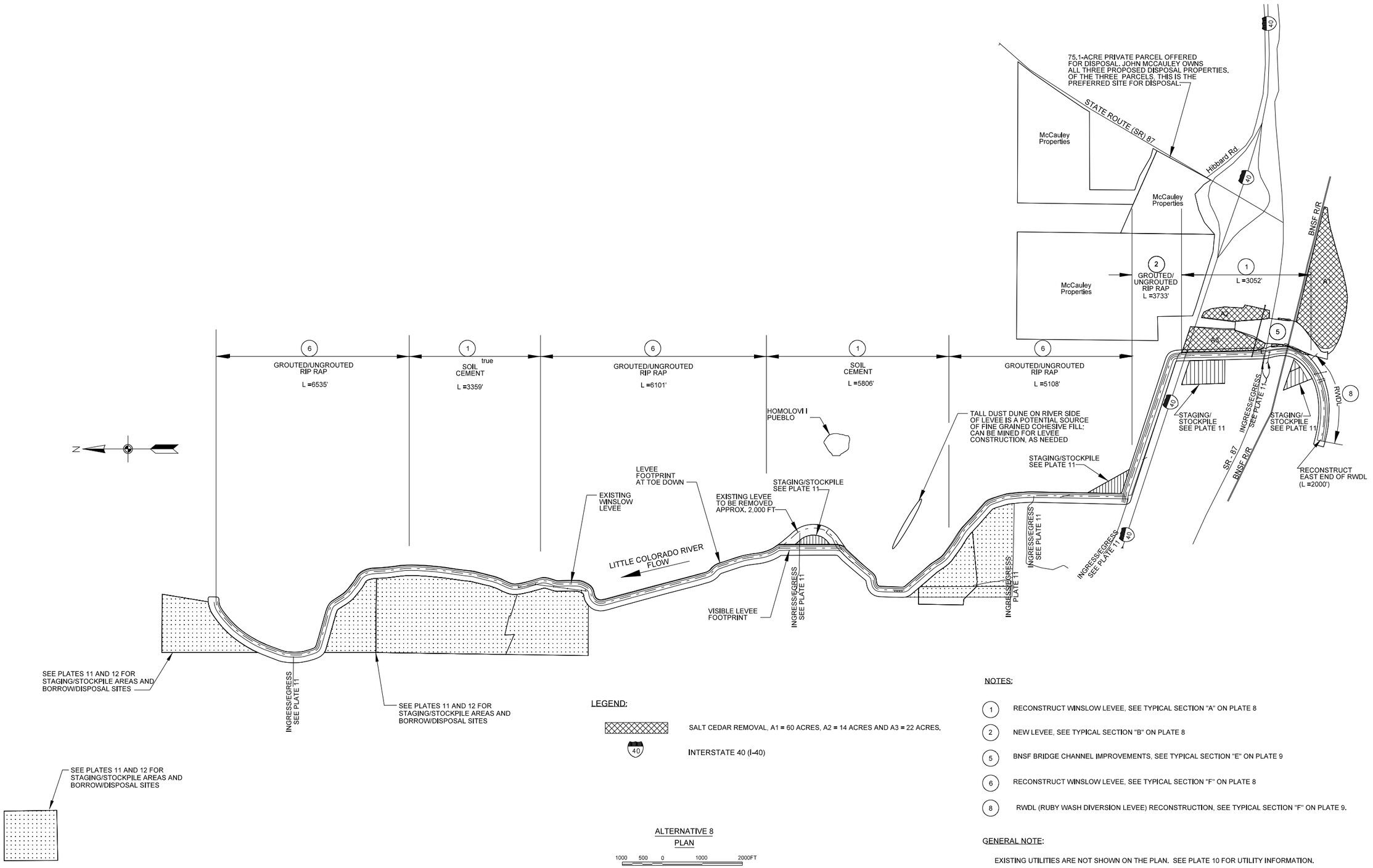
ALTERNATIVE 7
NONSTRUCTURAL MEASURES ONLY
PLAN

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

PLATE
4

Plot Date: $date$



LEGEND:

SALT CEDAR REMOVAL, A1 = 60 ACRES, A2 = 14 ACRES AND A3 = 22 ACRES.

INTERSTATE 40 (I-40)

ALTERNATIVE 8
PLAN

1000 500 0 1000 2000FT

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
5. BNSF BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_8.DGN

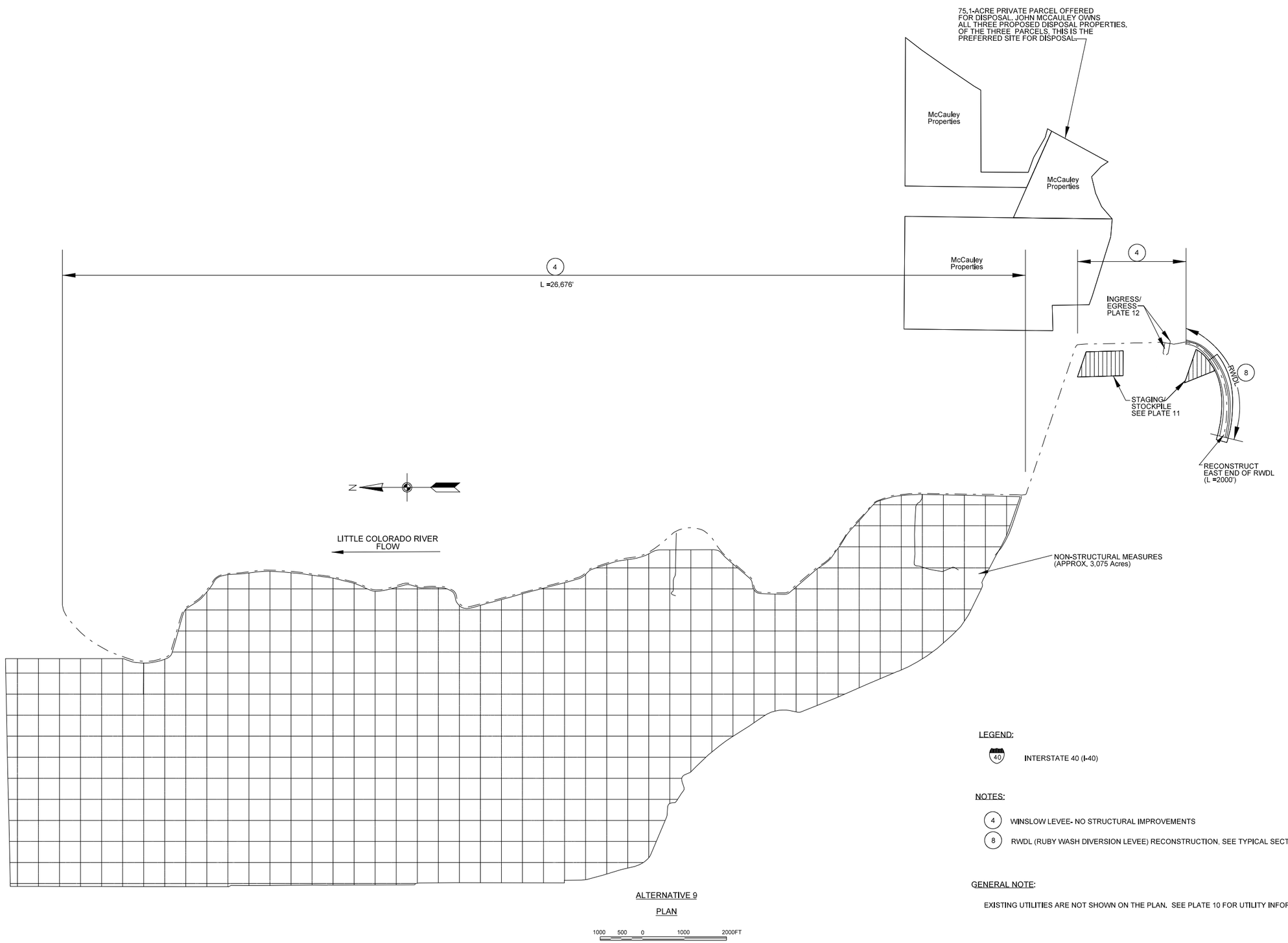
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

ALTERNATIVE 8
HOMOLOVI I LEVEE SETBACK
PLAN

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
5

Plot Date: $date$



ALTERNATIVE 9

PLAN

1000 500 0 1000 2000FT

LEGEND:

40 INTERSTATE 40 (I-40)

NOTES:

4 WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS

8 RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

DESIGNED BY:

DRAWN BY:

CHECKED BY:

FILE NAME: ALT_9.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

ALTERNATIVE 9
LEVEE INCREMENT 1

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

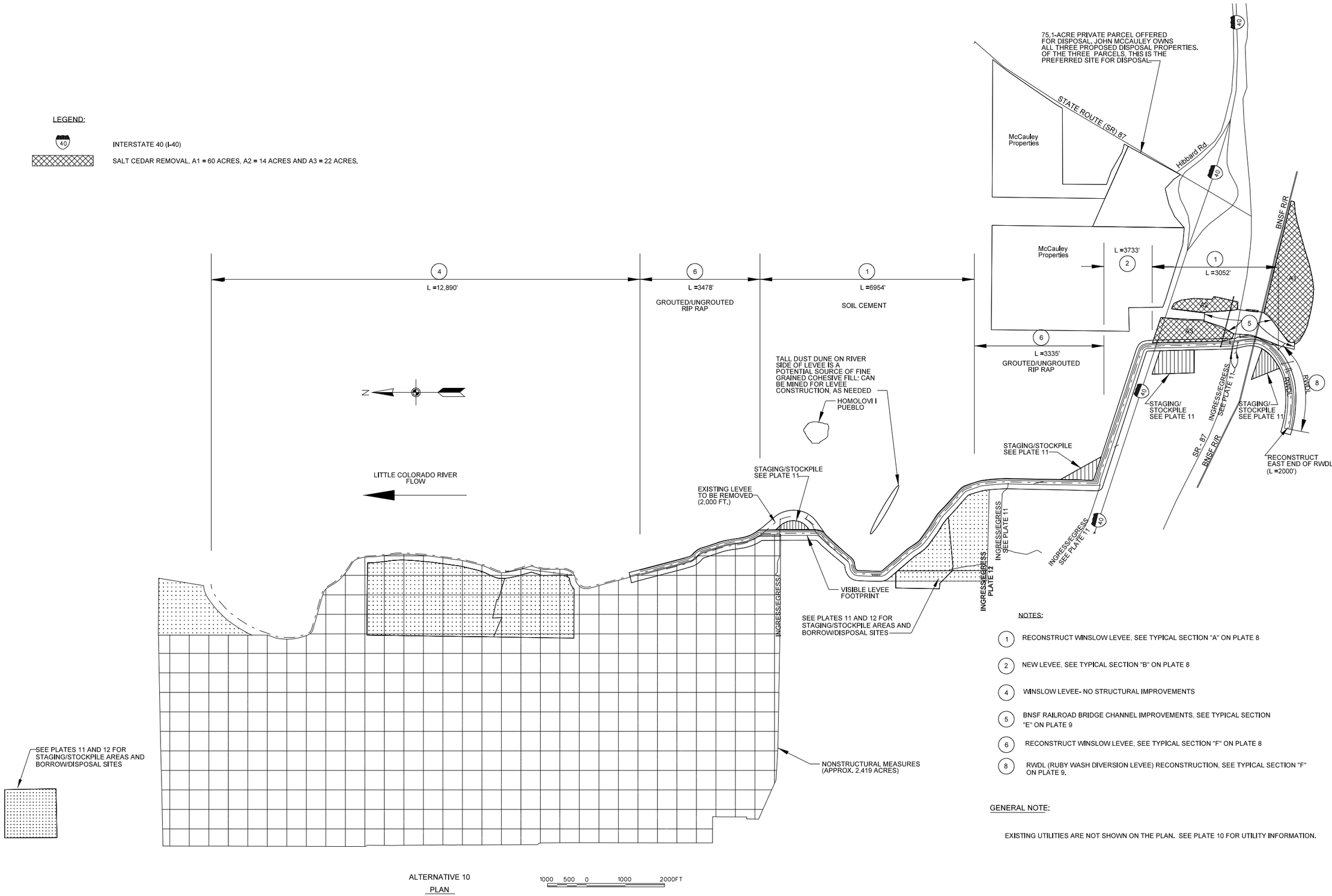
PLATE
6

Plot Date: $date$

LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 60 ACRES, A2 = 14 ACRES AND A3 = 22 ACRES.



ALTERNATIVE 10
PLAN

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
4. WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS
5. BNSF RAILROAD BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

DESIGNED BY:
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CHECKED BY:
FILE NAME: ALT_10.DGN

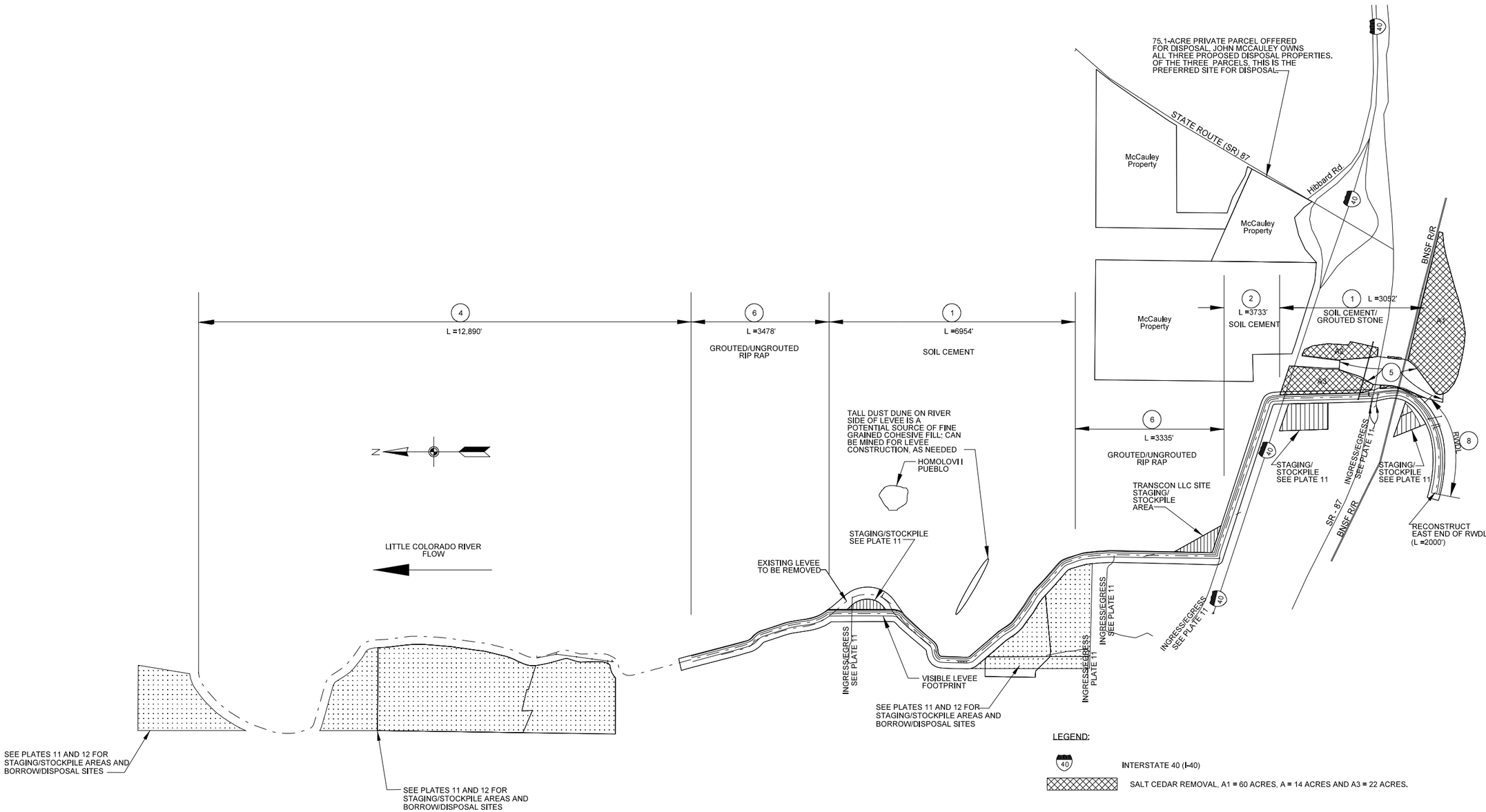
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

ALTERNATIVE 10
LEVEE INCREMENTS 1 & 2

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
7

Plot Date: $date$



LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 60 ACRES, A = 14 ACRES AND A3 = 22 ACRES.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
4. WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS
5. BNSF RAILROAD BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

ALTERNATIVE 10.1

PLAN

1000 500 0 1000 2000FT

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_10.1.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

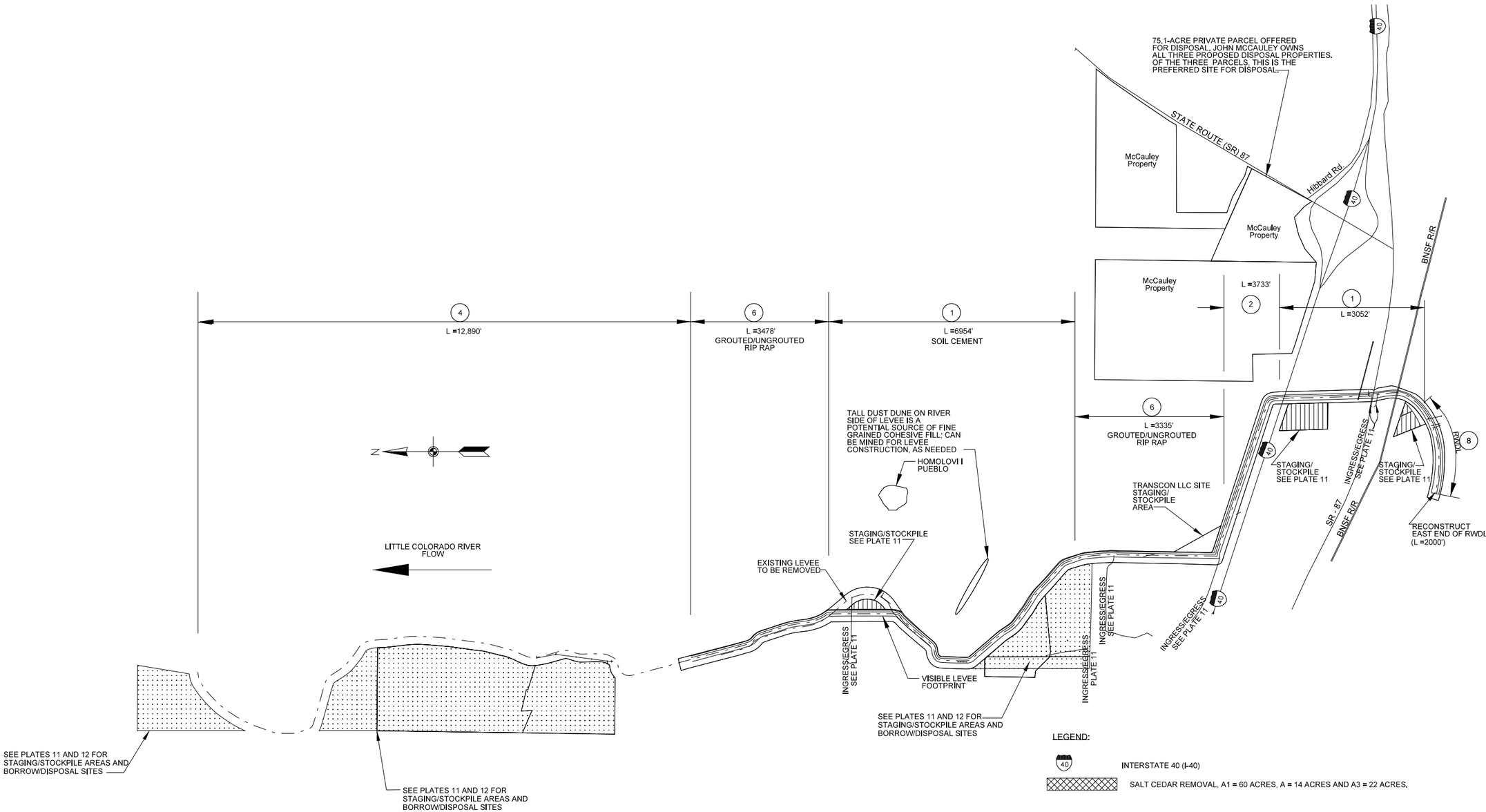
ALTERNATIVE 10.1
LEVEE INCREMENTS 1 & 2
1% ACE
100-YR LEVEE HEIGHTS

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN

PLATE
7.1

Plot Date: $date$



LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 60 ACRES, A = 14 ACRES AND A3 = 22 ACRES.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
4. WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS
5. BNSF RAILROAD BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

ALTERNATIVE 10.2
PLAN

1000 500 0 1000 2000FT

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_7_2.DGN

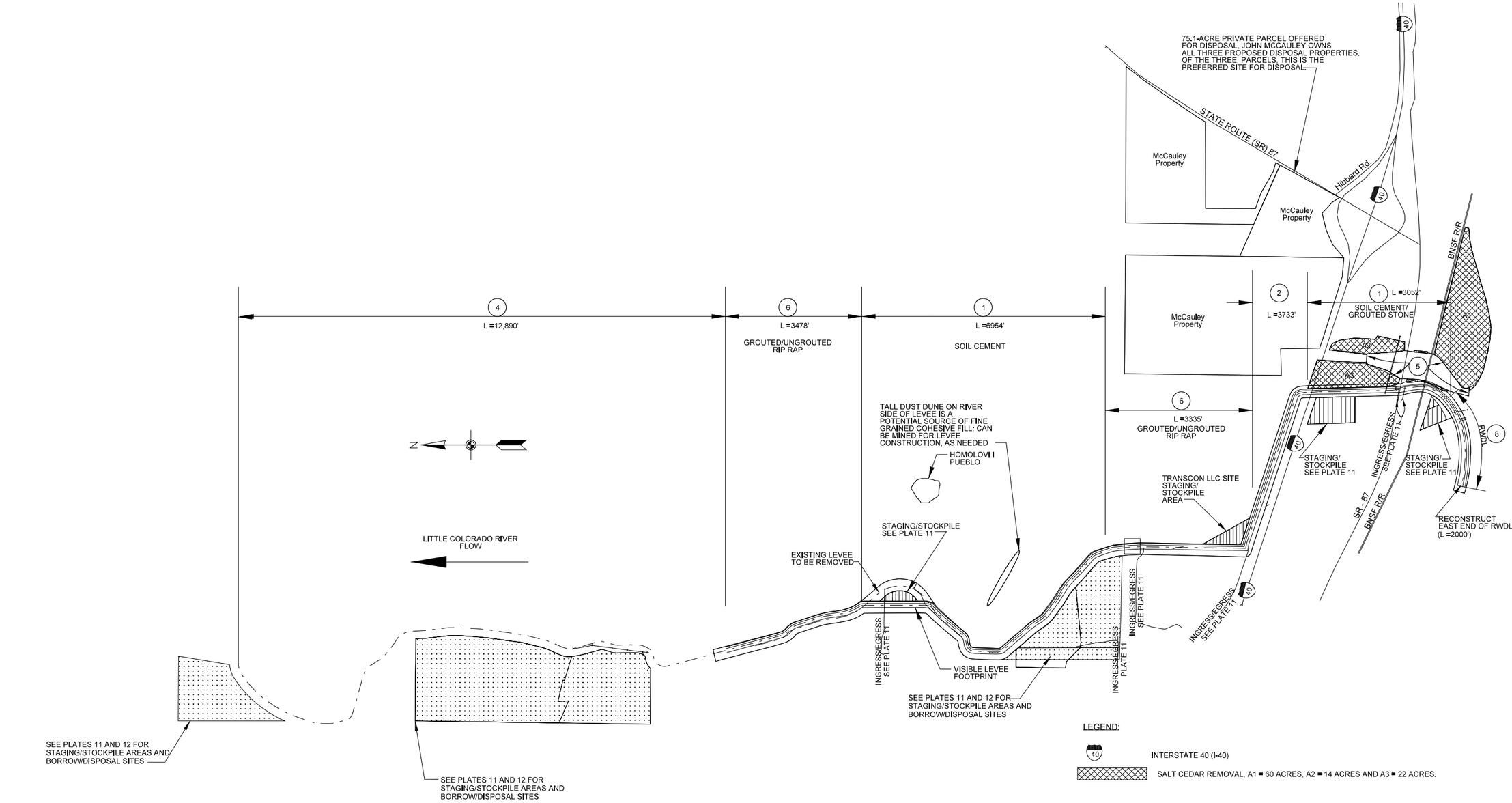
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

ALTERNATIVE 10.2
LEVEE INCREMENTS 1 & 2
4% ACE 25-YR LEVEE HEIGHTS

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
7.2

Plot Date: $date$



LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 60 ACRES, A2 = 14 ACRES AND A3 = 22 ACRES.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
4. WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS
5. BNSF RAILROAD BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

ALTERNATIVE 10.3
PLAN

1000 500 0 1000 2000FT

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_10.3.DGN

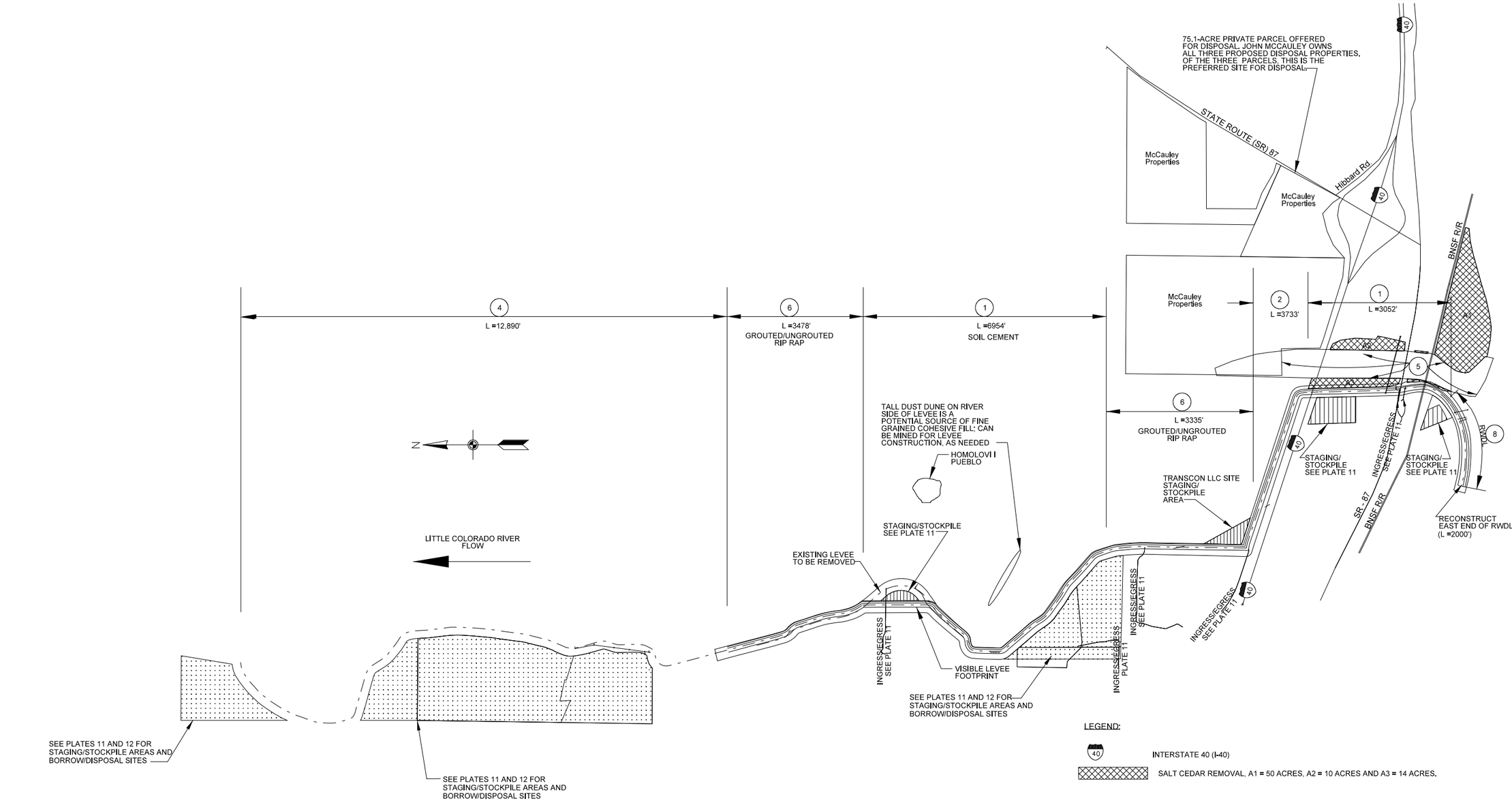
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

ALTERNATIVE 10.3
LEVEE INCREMENTS 1 & 2
2% ACE 50-YR LEVEE HEIGHTS

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
7.3

Plot Date: $date$



LEGEND:

40 INTERSTATE 40 (I-40)

SALT CEDAR REMOVAL, A1 = 50 ACRES, A2 = 10 ACRES AND A3 = 14 ACRES.

GENERAL NOTE:

EXISTING UTILITIES ARE NOT SHOWN ON THE PLAN. SEE PLATE 10 FOR UTILITY INFORMATION.

NOTES:

1. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "A" ON PLATE 8
2. NEW LEVEE, SEE TYPICAL SECTION "B" ON PLATE 8
4. WINSLOW LEVEE- NO STRUCTURAL IMPROVEMENTS
5. BNSF RAILROAD BRIDGE CHANNEL IMPROVEMENTS, SEE TYPICAL SECTION "E" ON PLATE 9
6. RECONSTRUCT WINSLOW LEVEE, SEE TYPICAL SECTION "F" ON PLATE 8
8. RWDL (RUBY WASH DIVERSION LEVEE) RECONSTRUCTION, SEE TYPICAL SECTION "F" ON PLATE 9.

ALTERNATIVE 10.4
PLAN

1000 500 0 1000 2000FT

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: ALT_10.4.DGN

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

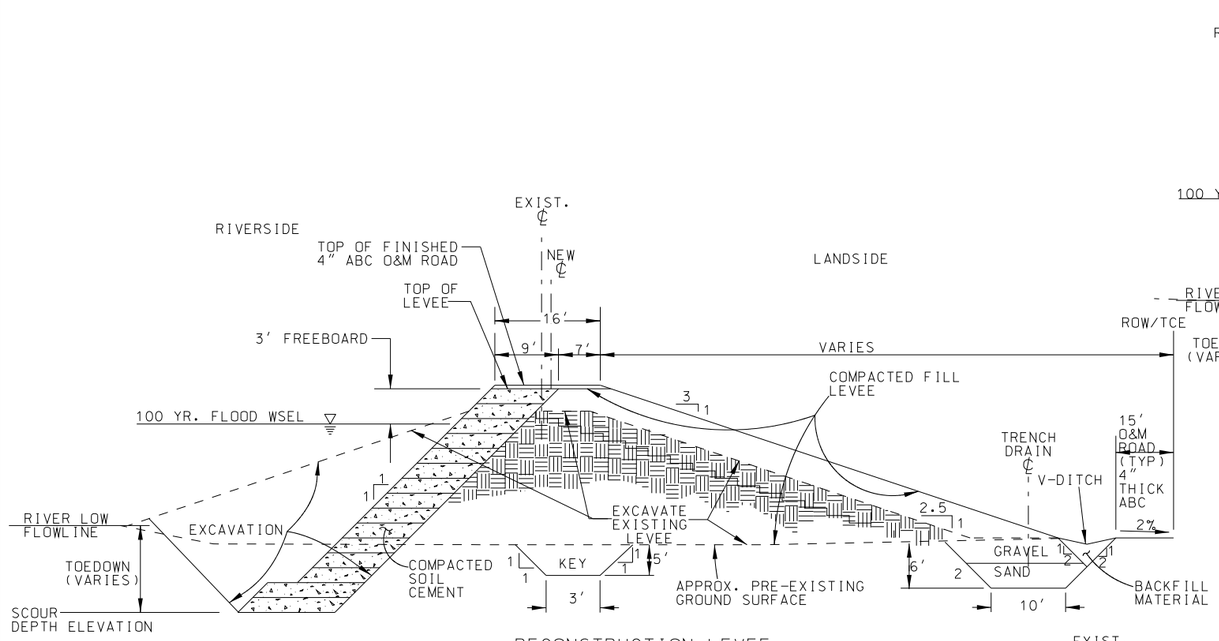
ALTERNATIVE 10.4
LEVEE INCREMENTS 1 & 2
0.5% ACE 200-YR LEVEE HEIGHTS

US Army Corps of Engineers
Los Angeles District

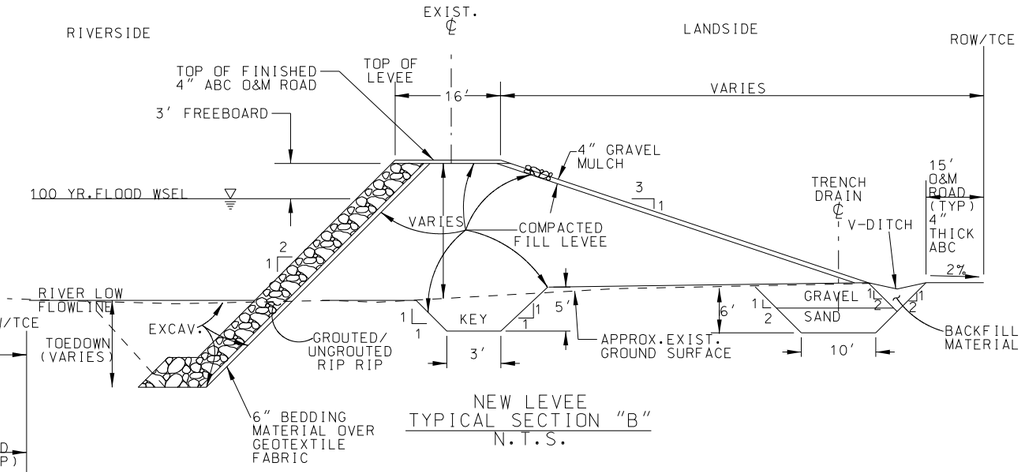
Scale: AS SHOWN

PLATE
7.4

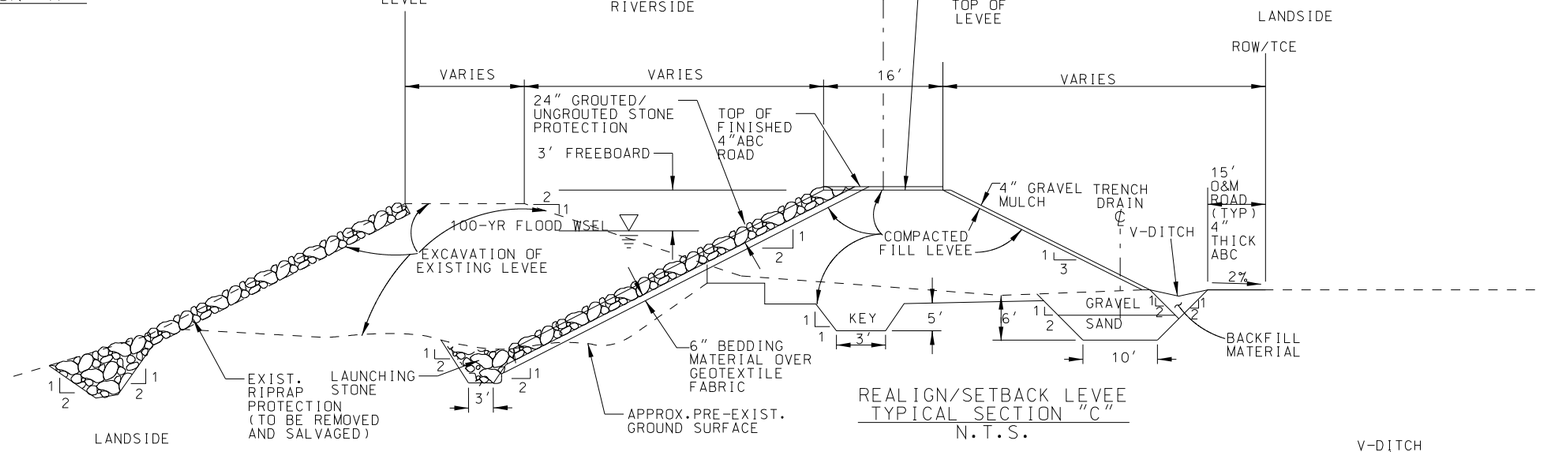
Plot Date: $date$



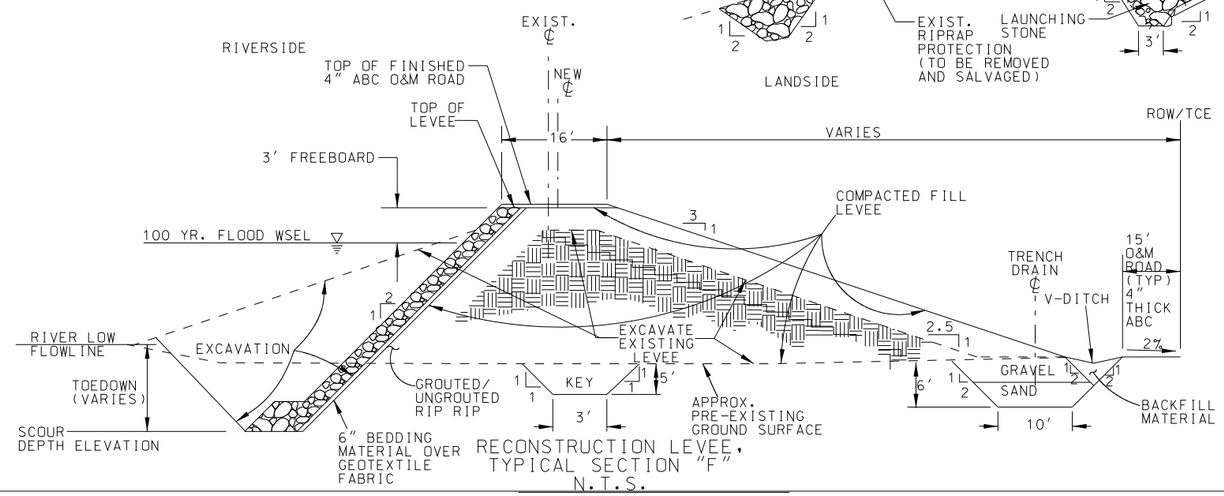
RECONSTRUCTION LEVEE,
TYPICAL SECTION "A"
N.T.S.



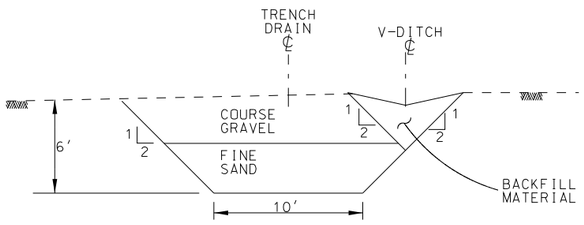
NEW LEVEE
TYPICAL SECTION "B"
N.T.S.



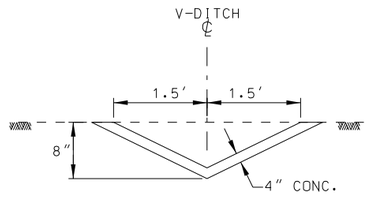
REALIGN/SETBACK LEVEE
TYPICAL SECTION "C"
N.T.S.



RECONSTRUCTION LEVEE,
TYPICAL SECTION "F"
N.T.S.



TRENCH DRAIN TYP SECTION
N.T.S.



V-DITCH TYP SECTION
N.T.S.

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FILE NAME:

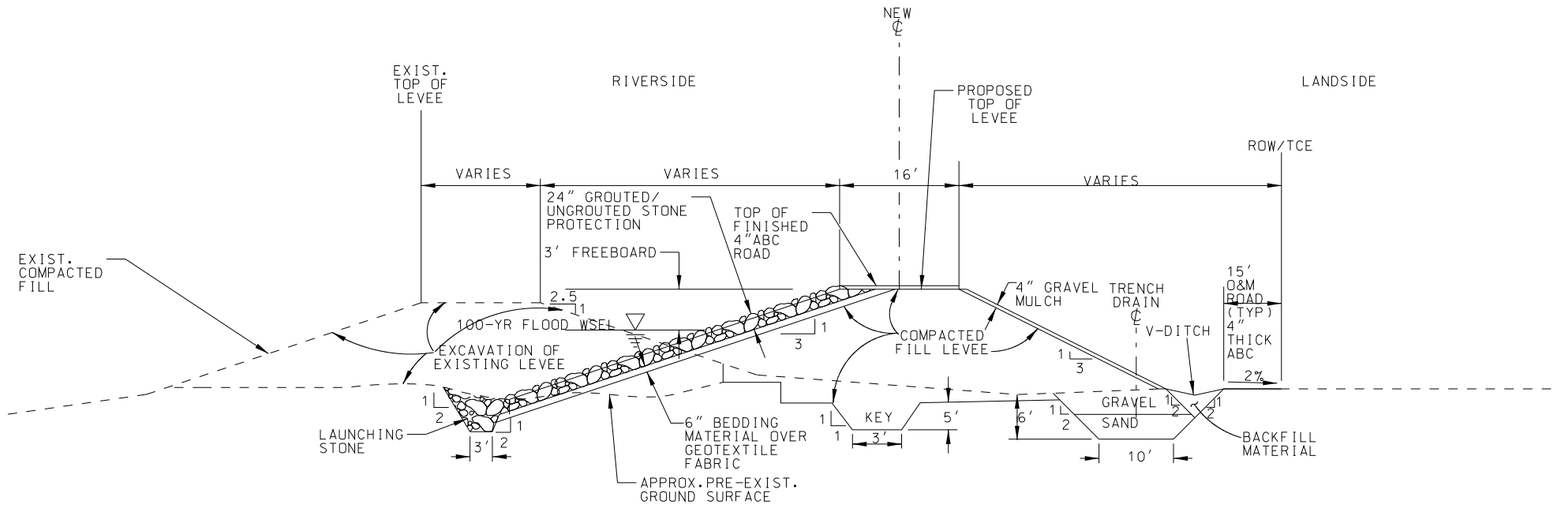
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

TYPICAL LEVEE SECTIONS

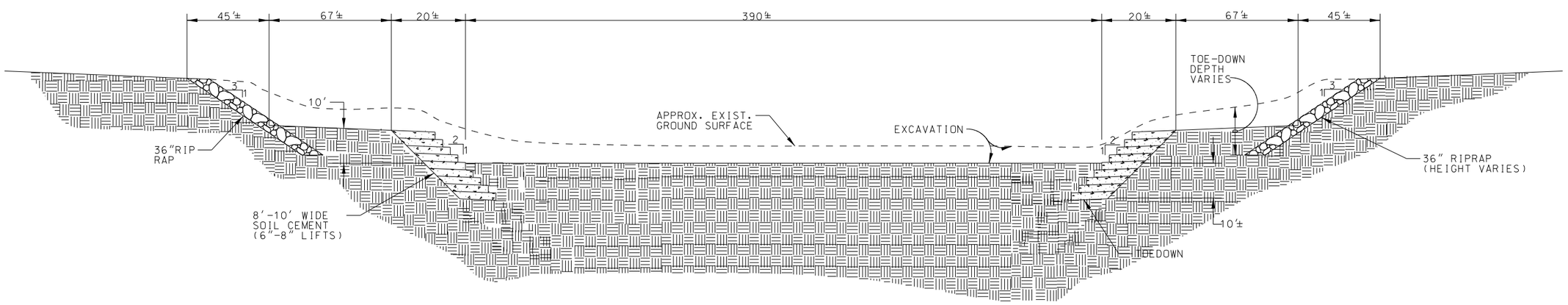
US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE 8

Plot Date: $date$



REALIGN/SETBACK LEVEE
TYPICAL SECTION "D"
N.T.S.



CHANNELIZATION
TYPICAL SECTION "E"
N.T.S.

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME:

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

TYPICAL SETBACK LEVEE AND
CHANNELIZATION SECTIONS

US Army Corps
of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
9

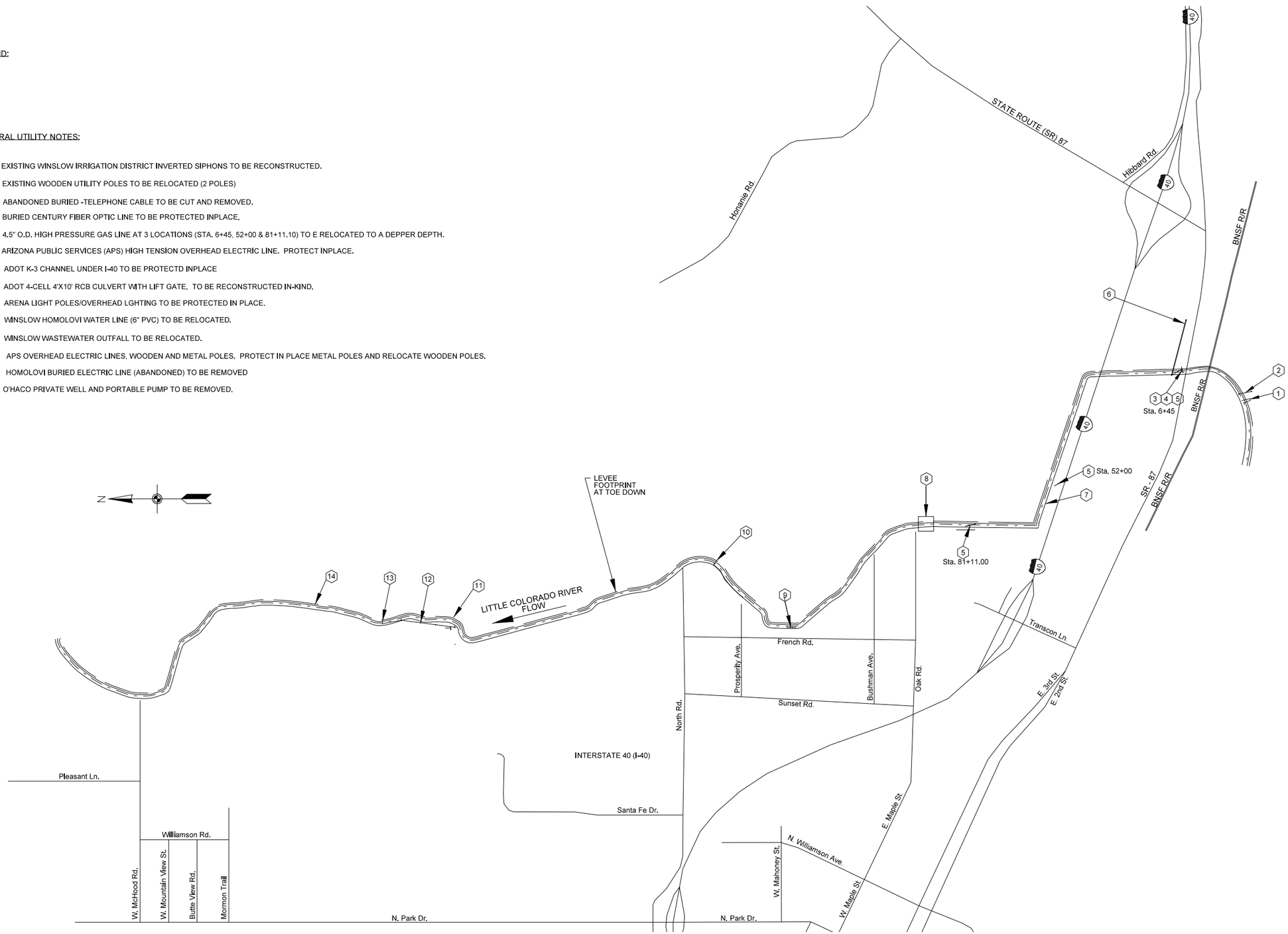
Plot Date: $date$

LEGEND:

40

GENERAL UTILITY NOTES:

1. EXISTING WINSLOW IRRIGATION DISTRICT INVERTED SIPHONS TO BE RECONSTRUCTED.
2. EXISTING WOODEN UTILITY POLES TO BE RELOCATED (2 POLES)
3. ABANDONED BURIED -TELEPHONE CABLE TO BE CUT AND REMOVED.
4. BURIED CENTURY FIBER OPTIC LINE TO BE PROTECTED INPLACE.
5. 4.5" O.D. HIGH PRESSURE GAS LINE AT 3 LOCATIONS (STA. 6+45, 52+00 & 81+11.10) TO E RELOCATED TO A DEPPER DEPTH.
6. ARIZONA PUBLIC SERVICES (APS) HIGH TENSION OVERHEAD ELECTRIC LINE. PROTECT INPLACE.
7. ADOT K-3 CHANNEL UNDER I-40 TO BE PROTECTD INPLACE
8. ADOT 4-CELL 4'X10' RCB CULVERT WITH LIFT GATE. TO BE RECONSTRUCTED IN-KIND.
9. ARENA LIGHT POLES/OVERHEAD LGHTING TO BE PROTECTED IN PLACE.
10. WINSLOW HOMOLOVI WATER LINE (6" PVC) TO BE RELOCATED.
11. WINSLOW WASTEWATER OUTFALL TO BE RELOCATED.
12. APS OVERHEAD ELECTRIC LINES, WOODEN AND METAL POLES. PROTECT IN PLACE METAL POLES AND RELOCATE WOODEN POLES.
13. HOMOLOVI BURIED ELECTRIC LINE (ABANDONED) TO BE REMOVED
14. O'HACO PRIVATE WELL AND PORTABLE PUMP TO BE REMOVED.



EXISTING UTILITIES

DESIGNED BY:
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CHECKED BY:
FILE NAME: Existing Utilities.DGN

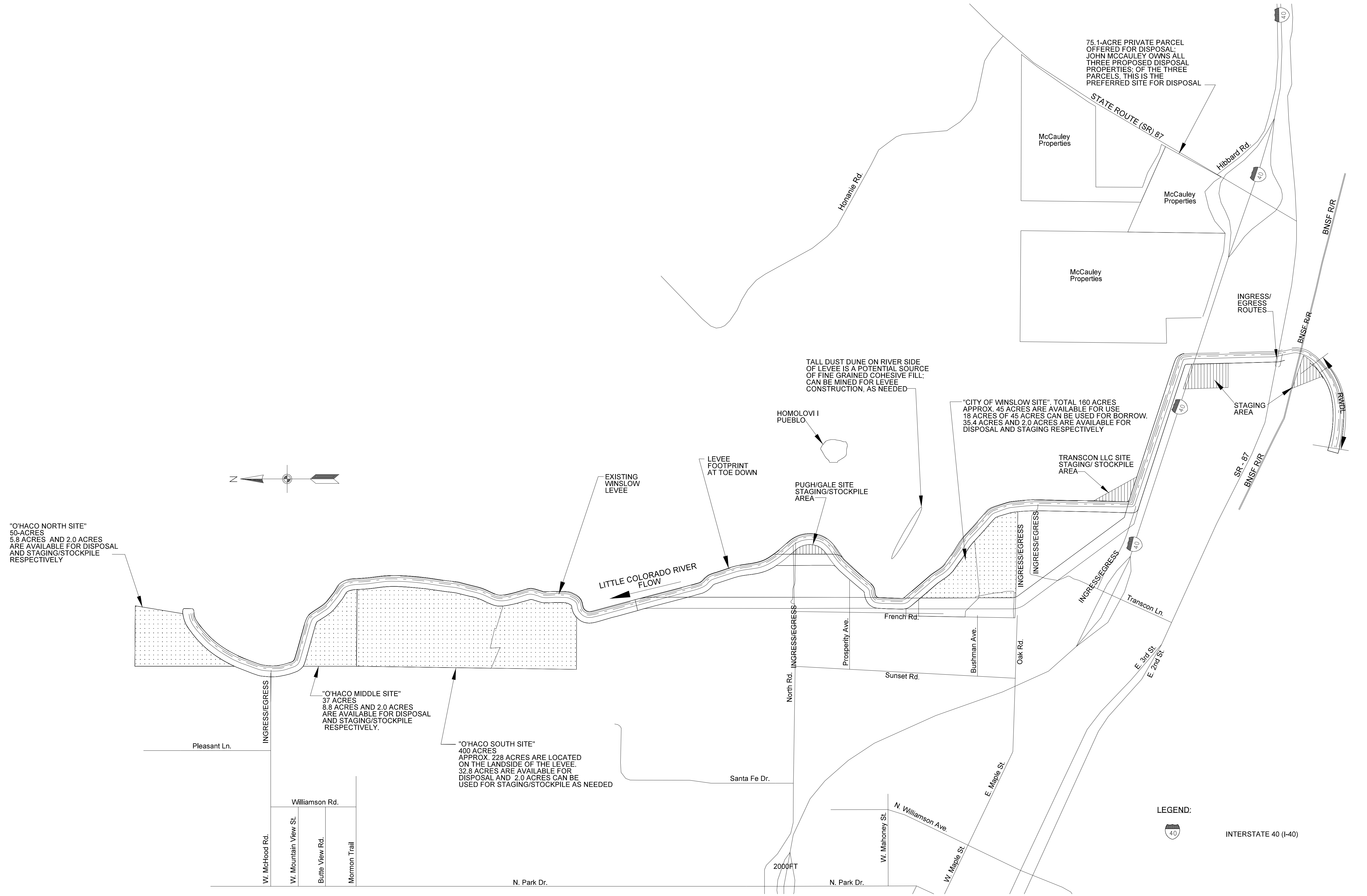
LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

EXISTING UTILITIES

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
10

Plot Date: $date$



75.1-ACRE PRIVATE PARCEL OFFERED FOR DISPOSAL; JOHN MCCAULEY OWNS ALL THREE PROPOSED DISPOSAL PROPERTIES; OF THE THREE PARCELS, THIS IS THE PREFERRED SITE FOR DISPOSAL
STATE ROUTE (SR) 87
McCauley Properties
McCauley Properties
McCauley Properties
Hibbard Rd.
Honanie Rd.
BNSF R/R
INGRESS/ EGRESS ROUTES
BNSF R/R
STAGING AREA
RWDL
TALL DUST DUNE ON RIVER SIDE OF LEVEE IS A POTENTIAL SOURCE OF FINE GRAINED COHESIVE FILL; CAN BE MINED FOR LEVEE CONSTRUCTION, AS NEEDED
"CITY OF WINSLOW SITE", TOTAL 160 ACRES APPROX. 45 ACRES ARE AVAILABLE FOR USE 18 ACRES OF 45 ACRES CAN BE USED FOR BORROW. 35.4 ACRES AND 2.0 ACRES ARE AVAILABLE FOR DISPOSAL AND STAGING RESPECTIVELY
HOMOLOVI I PUEBLO
TRANSCON LLC SITE STAGING/ STOCKPILE AREA
SR - 87
BNSF R/R
N
EXISTING WINSLOW LEVEE
LEVEE FOOTPRINT AT TOE DOWN
PUGH/GALE SITE STAGING/STOCKPILE AREA
LITTLE COLORADO RIVER FLOW
"O'HACO NORTH SITE" 50-ACRES 5.8 ACRES AND 2.0 ACRES ARE AVAILABLE FOR DISPOSAL AND STAGING/STOCKPILE RESPECTIVELY
INGRESS/EGRESS
INGRESS/EGRESS
INGRESS/EGRESS
INGRESS/EGRESS
INGRESS/EGRESS
Transcon Ln.
French Rd.
Prosperity Ave.
Bushman Ave.
Oak Rd.
Sunset Rd.
North Rd.
E. 3rd St.
E. 2nd St.
"O'HACO MIDDLE SITE" 37 ACRES 8.8 ACRES AND 2.0 ACRES ARE AVAILABLE FOR DISPOSAL AND STAGING/STOCKPILE RESPECTIVELY.
"O'HACO SOUTH SITE" 400 ACRES APPROX. 228 ACRES ARE LOCATED ON THE LANDSIDE OF THE LEVEE. 32.8 ACRES ARE AVAILABLE FOR DISPOSAL AND 2.0 ACRES CAN BE USED FOR STAGING/STOCKPILE AS NEEDED
Pleasant Ln.
Santa Fe Dr.
Williamson Rd.
E. Maple St.
N. Williamson Ave.
W. Mahoney St.
W. Maple St.
W. McHood Rd.
W. Mountain View St.
Butte View Rd.
Mormon Trail
2000FT
N. Park Dr.
N. Park Dr.
LEGEND:
40
INTERSTATE 40 (I-40)

STAGING / STOCKPILE ARES
INGRESS / EGRESS ROUTES

PLAN

1000 500 0 1000

SCALE: 1" = 1000'

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: StagingStockpileIngressEgress.dgn

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

STAGING / STOCKPILE AREAS
AND INGRESS / EGRESS ROUTES

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
11

Plot Date: $date$

LEGEND:

40 INTERSTATE 40 (I-40)

N

"O'HACO NORTH SITE"
50-ACRES
5.8 ACRES AND 2.0 ACRES
ARE AVAILABLE FOR DISPOSAL
AND STAGING/STOCKPILE
RESPECTIVELY

"O'HACO NORTHWEST" SITE
A 39.2-ACRE PARCEL
FORMERLY MINED FOR LEVEE
CONSTRUCTION MATERIALS
WILL NOT USE MATERIAL FROM
THIS PARCEL UNLESS IT
CANNOT BE OBTAINED CLOSER
TO THE CONSTRCTION SITE

"O'HACO MIDDLE SITE"
37 ACRES
8.8 ACRES AND 2.0 ACRES
ARE AVAILABLE FOR DISPOSAL
AND STAGING/STOCKPILE
RESPECTIVELY.

"O'HACO SOUTH SITE"
400 ACRES
APPROX. 228 ACRES ARE LOCATED
ON THE LANDSIDE OF THE LEVEE.
32.8 ACRES ARE AVAILABLE FOR
DISPOSAL AND 2.0 ACRES CAN BE
USED FOR STAGING/STOCKPILE AS NEEDED

"CITY OF WINSLOW SITE": TOTAL 160 ACRES
APPROX. 45 ACRES ARE AVAILABLE FOR USE
18 ACRES OF 45 ACRES CAN BE USED FOR BORROW.
35.4 ACRES AND 2.0 ACRES ARE AVAILABLE FOR
DISPOSAL AND STAGING RESPECTIVELY

TALL DUST DUNE ON RIVER SIDE
OF LEVEE IS A POTENTIAL SOURCE
OF FINE GRAINED COHESIVE FILL:
CAN BE MINED FOR LEVEE
CONSTRUCTION, AS NEEDED

75.1-ACRE PRIVATE PARCEL
OFFERED FOR DISPOSAL:
JOHN MCCAULEY OWNS ALL
THREE PROPOSED DISPOSAL
PROPERTIES; OF THE THREE
PARCELS, THIS IS THE
PREFERRED SITE FOR DISPOSAL

JOHN MCCAULEY PROPERTY

JOHN MCCAULEY PROPERTY

JOHN MCCAULEY PROPERTY

LEVEE CONTROL LINE

LITTLE COLORADO RIVER FLOW

STATE ROUTE (SR) 87

Honanie Rd.

Hibbard Rd.

BNSF R/R

RR/DD

SR - 87

BNSF R/R

Transcon Ln.

French Rd.

Prosperity Ave.

Bushman Ave.

Oak Rd.

Sunset Rd.

North Rd.

E. 3rd St.

E. 2nd St.

E. Maple St.

Pleasant Ln.

Santa Fe Dr.

Williamson Rd.

W. McHood Rd.

W. Mountain View St.

Butte View Rd.

Mormon Trail

N. Park Dr.

N. Park Dr.

W. Mahoney St.

N. Williamson Ave.

W. Maple St.

Fire Mtn. Rd.

Mikes Pike Blvd.

W. Fleming St.

W. 3rd St.

S. Highway 87

BORROW/DISPOSAL SITES

PLAN

1000 500 0 1000 2000FT

SCALE: 1" = 1000'

DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NAME: BorrowDisposal.Dgn

LITTLE COLORADO RIVER AT WINSLOW FEASIBILITY STUDY
WINSLOW, ARIZONA

BORROW / DISPOSAL SITE

US Army Corps of Engineers
Los Angeles District

Scale: AS SHOWN
PLATE
12

Plot Date: $date$

Sunset Rd.